AGRONOMY SEMINAR
305 DAVENPORT HALL

ОЧВОВЕДЕНИЕ

SOVIET SOIL SCIENCE

12

DECEMBER 1958

A TRANSLATION
OF POCHVOVEDENIYE

★

AMERICAN INSTITUTE
OF BIOLOGICAL SCIENCES
2000 P STREET, N.W.
WASHINGTON 6, D. C.

SOVIET SOIL SCIENCE

A. P. MAZURAK, *Editor*
Department of Agronomy, University of Nebraska

Patricia Haley
Assistant Editor

American Institute of Biological Sciences

Officers
James G. Dickson, *President*
Paul J. Kramer, *Vice-President*
F. P. Cullinan, *Secretary-Treasurer*

Executive Director
Hiden T. Cox

Chairman,
Committee on Translations
Fred R. Cagle

Director of Publications
Francis C. Harwood

Governing Board
Robert Briggs
T. C. Byerly
Fred R. Cagle
John N. Couch
H. Clark Dalton
David E. Davis
Wallace O. Fenn
Charles B. Heiser
Freeman S. Howlett
Paul Kramer
Ernest A. Lachner
Elbert L. Little, Jr.
W. Gardner Lynn
Dorothy Matala
J. M. McGuire
George L. McNew
Bernard S. Meyer
Fred S. Orcutt
F. W. Poos
Karl A. Stiles
Carl P. Swanson
A. C. Walton
F. W. Went

The translation and publication of this and other Russian language biological journals and monographs is a project of the American Institute of Biological Sciences. This project is supported by grants from the National Science Foundation. Each publication is a cover-to-cover translation of its Soviet counterpart and the contents are only those of the original authors.

Pochvovedeniye in English translation bears the Soviet issue numbers. The Soviet journal carries no volume numbers. Translation begins with Number 1, the January 1958 issue. It is published in the same number of issues per year as the original Soviet journals: 12 issues.

translated and produced by
ROYER & ROGER, INC.
INTERNATIONAL DIVISION

Subscription Prices:
$40.00 per year, individuals and industrial libraries
20.00 per year, university and non-profit libraries
3.00 additional to each price for foreign orders
4.50 each, single copies

Order from:

American Institute of Biological Sciences
2000 P Street, N.W., Washington 6, D.C.

© 1960 American Institute of Biological Sciences

SOVIET SOIL SCIENCE

A translation of the monthly journal—POCHVOVEDENIYE—a publication of the V. V. Dokuchayev Institute of Soil Science, Academy of Sciences, USSR. A journal founded in 1899.

Pochvovedeniye Editorial Board: I. V. Tyurin (editor-in-chief), I. N. Antipov-Karatayev, N. I. Gorbunov, K. P. Gorshenin. A. A. Zavalishin, V. N. Zavaritskii, S. V. Zonn (assistant editor), O. K. Kedrov-Zikhman, V. M. Klechkovskii, V. A. Kovda, M. M. Kononova (assistant editor), Ya. V. Peive, I. I. Sinyagin, A. V. Sokolov

---

Number 12: December 1958 **Translation printed: August 1960**

CONTENTS

	Page	Russian Page
FORMATION AND MIGRATION OF ORGANIC IRON COMPOUNDS IN SOILS, by I. S. Kaurichev, Ye. V. Kulakov, and Ye. M. Nozdrunova	1307	1
THE MINOR BIOLOGICAL CYCLE OF ASH ELEMENTS AND NITROGEN IN THE PROCESSES OF MEADOW-STEPPE AND STEPPE SOIL FORMATION, by N. I. Basilevich	1314	9
PROBLEMS AND METHODS OF MICROSCOPIC AND MINERALOGIC SOIL INVESTIGATIONS, by Ye. I. Parfenova and Ye. A. Yarilova	1331	28
OXYGEN CONTENT IN GROUND WATERS OF SOME FOREST SOIL GROUPS OF THE VOLOGDA OBLAST', by A. Ya. Orlov	1339	36
DISCUSSION		
AN ATTEMPT AT A SYSTEMATIC CLASSIFICATION OF THE SOILS IN THE STEPPE ZONE OF THE USSR, by Ye. N. Ivanova and N. N. Rozov	1349	48
SEASONAL CHANGES IN COMPOSITION OF ORGANIC MATTER IN DRAINED, CULTIVATED BOG SOILS, by T. A. Nikolayeva	1359	60
A STUDY OF THE MINOR ELEMENT CONTENTS IN SOILS OF THE AMUR RIVER AREA, by V. A. Kovda and V. D. Vasil'yevskaya	1369	68
BIOPHYSICAL AND CHEMICAL ANALYSIS OF SOIL AGGREGATES, by M. G. Tyagny-Ryando	1378	76

Page Russian Page

REVIEWS

SOIL COLLOIDS. POPULAR SCIENTIFIC SERIES OF THE PRESS OF THE ACADEMY OF SCIENCES, USSR. 1957, by N. I. Gorbunov 1388 85

SOIL COLLOIDS AND THE ABSORPTIVE CAPACITIES OF SOILS. STATE PRESS OF AGRICULTURAL LITERATURE. 1957, by Professor N. P. Remezov 1390 86

CHRONICLE

THE SEVENTIETH BIRTHDAY OF IVAN NIKOLAYEVICH ANTIPOV-KARATAYEV, by the Editorial Staff of Pochvovedeniye 1395 91

THE RESULTS OF THE FIRST INTER-OBLAST' CONFERENCE OF SOIL SCIENTISTS OF THE CENTRAL CHERNOZEM ZONE, by P. G. Aderikhin 1397 92

THE ACTIVITIES OF THE TURKMENIAN BRANCH OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS, by O. M. Dzhumayev 1399 94

THE ACTIVITIES OF THE GEORGIAN BRANCH OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS, by D. P. Gedevanishvili 1400 94

THE WORK OF THE KOMI SECTION OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS IN 1957, by I. V. Zaboyeva 1402 95

THE WORK OF THE KIEV SECTION OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS, by G. N. Sambur 1403 96

THE WORK OF THE ROSTOV SECTION OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS, by P. A. Sadimenko 1404 97

THE WORK OF THE PENZA SECTION OF THE ALL-UNION ASSOCIATION OF SOIL SCIENTISTS, by K. A. Kuznetsov 1406 98

BIBLIOGRAPHY 1407 99

INDEX 1415 106

FORMATION AND MIGRATION OF ORGANIC IRON COMPOUNDS IN SOIL[1]

I. S. KAURICHEV, YE. V. KULAKOV, YE. M. NOZDRUNOVA
K. A. Timiryazev Moscow Agricultural Academy

The problems of the migration of iron have always attracted the attention of soil scientists because of the widespread distribution of the displacement and deposition of iron in nature and their great importance in the genesis of a number of soil groups (podzolic and swampy soils, soloths, solonetz, etc.), as well as the great complexity of these processes.

The majority of investigators recognize that water-soluble organic substances in the soil play an important role in the migration of iron (1, 2, 3, 7, 8, 13, 14, 15, 18, 20, 21, 22). Since the transformation of iron compounds in the soil is associated with the ability of iron to pass from the ferric to the ferrous form and back again, much attention has also been devoted to discovering the conditions governing the formation of ferrous iron compounds in the soil and the possibility of their movement (3, 4, 5, 6, 9, 10, 11). Most of the papers on this subject note the instability of the ferrous iron compounds in the soil because of their rapid transformation into the ferric form; this is the reason for the small role played by these forms in the migration of iron.

For a number of years the Department of Soil Science and the V. R. Vil'yams Museum of the K. A. Timiryazev Moscow Agricultural Academy, under the direction of S. P. Yarkov, have investigated the conditions of formation of soluble iron compounds and the possibility of the migration of iron in the soil (12, 20, 21, 22, 23).

This article presents results of a three-year observation of the dynamics of oxidation-reduction in sod-podzolic soils, as well as data on laboratory experiments to determine the possibility of the formation of organic iron compounds during the course of temporary reducing processes in the soil.[2]

It is known that ferrous iron compounds are formed as a result of biochemical processes during the course of temporary anaerobiosis in the soil. Laboratory experiments were conducted to study the ability of water-soluble organic products of the decomposition of plant residues to extract ferrous iron from gley soil. The method used in these experiments was as follows. Plant residues (fir needles, birch leaves, clover hay and timothy) in the amount of 25 g of air-dried material were decomposed under various conditions of moisture: optimal (aerobic conditions) and excess (anaerobic conditions). The magnitude of the oxidation-reduction potential served as the control for the anaerobic conditions. The durations of the experiments were 1 month, 3 months and 1 year.

At the conclusion of the experiments, water extracts with a ratio of 1:40 between the water and the original organic mass and with five-minute agitation were prepared from the plant residues in various stages of decomposition. The extracts were filtered and the pH, the sesquioxides and the organic matter recalculated as carbon were determined.

The extracts thus obtained were allowed to react with gley soil (sod-podzolic soil from the Aplowed horizon, 0-20 cm, in the fields of the Timiryazev Agricultural Academy farm) with a soil-solution ratio of 1:2.5. The organic matter and the FeO and Fe_2O_3 in the filtrate, the latter two colorimetrically with α-α'-dipyridyl, were determined. The results of the experiments are given in Table 1. These figures show that in the decomposition of the plant residues under conditions of excess moisture a considerably greater quantity of water-soluble organic compounds is formed, especially during the first period of decomposition (one month and three months). One may also note a definite regularity in the ability of the water-soluble products of the decomposition of plant residues to extract ferrous iron from gley soil. The products of anaerobic decomposition extract ferrous iron in much greater quantities. This important difference between the products of aerobic and anaerobic decomposition is observed in the reaction of gley soil both with original extracts from decomposed plant residues and with extracts containing equal amounts of organic matter in terms of carbon content. When gley soil reacted with water-soluble products of the decomposition of plant residues, different forms of iron, possessing different stabilities and thus different migrating capacities through the soil profile, pass into the extract. The most interesting in this regard are the so-called fixed forms of iron (18).

---

[1] Report to the First Congress of Delegates of Soil Scientists, May 1958.

[2] Senior Laboratory Technicians M. N. Rytikova and A. F. Shemyakina took part in the analysis of the data.

Table 1

FeO extraction from gley soil by water-soluble products of plant residue decomposition

Plant residues	Conditions and stage of decomposition	pH	Organic matter in g C/l	FeO in mg/100 g absolutely dry soil	
				Solution	
				Original concentration	Concentration adjusted for C
	One month				
Clover and timothy	Aerobic	7.9	0.142	3.4	1.8
	Anaerobic	5.15	0.414	8.15	6.8
Fir needles	Aerobic	5.55	0.065	5.4	5.4
	Anaerobic	5.32	0.241	6.0	3.26
Birch leaves	Aerobic	7.55	0.170	3.4	2.45
	Anaerobic	6.76	0.409	4.72	3.26
	Three months				
Clover and timothy	Aerobic	7.95	0.203	2.21	1.33
	Anaerobic	5.25	0.605	15.5	4.65
Fir needles	Aerobic	4.6	0.154	2.76	2.76
	Anaerobic	5.3	0.476	6.65	2.33
Birch leaves	Aerobic	5.65	0.248	3.32	1.66
	Anaerobic	6.4	0.767	2.21	2.33
	One year				
Clover and timothy	Aerobic	8.5	0.238	3.9	0.166
	Anaerobic	5.5	0.095	1.07	0.125
Fir needles	Aerobic	4.8	0.084	1.07	0.125
	Anaerobic	4.7	0.073	1.43	1.43
Birch leaves	Aerobic	7.2	0.223	1.07	0.18
	Anaerobic	6.7	0.270	1.43	0.125

In order to determine the possibility of the formation of fixed forms of iron in the soil reaction with the decomposition products of plant residues, along with the determination of the iron content directly in the extract, the iron was determined in the same extract after the organic matter destruction by hydrogen peroxide. The results are given in Table 2.

Table 2 shows that in the reaction of the soil with the decomposition products of plant residues a large amount of iron combined with organic matter. The iron content is especially high in the case of the anaerobic decomposition products of fir needles.

The fixed iron is in the form of organic iron compounds which are apparently mainly of a complex character. An electrodialysis was made by the authors (Table 3) to find the characteristic features of this condition.

The artificial solutions were obtained by the reaction of water-soluble products of the decomposition of plant residues on gley soil.

The natural solutions represent top water layers taken in peaty gley soil and carefully

Table 2

Content of fixed iron extracted by solutions from gley soil

Plant material	Decomposition conditions	FeO in mg/100 g soil		
		Filtrate		Fixed iron
		Before oxidation	After oxidation	
Clover and timothy	Aerobic	4.13	7.5	3.77
	Anaerobic	8.84	10.1	1.26
Fir needles	Aerobic	5.4	5.6	0.2
	Anaerobic	6.0	10.5	4.5
Birch leaves	Aerobic	4.8	9.0	4.2
	Anaerobic	7.66	7.75	2.09
Water extract	—	2.03	2.25	0.22

Table 3

Iron content in the anolyte in the dialysis of the solutions

Solutions	Dialysis duration, hours	Iron as FeO, mg/l	
		In original solution	In anolyte
	Artificial		
Experiment 1	10	107.0	48.5
Experiment 2	7	18.0	8.0
Experiment 3	7	14.0	traces
	Natural		
a) Top water layer taken in September	13	5.5	1.0
b) Top water layer taken in May	6	9.0	1.5

filtered through fine filters.

Electrodialysis of the top water layer and the artificial solutions has shown that the soluble iron combined with organic matter is not only a cation, but also enters into the composition of the complex organic-iron anion, as indicated by the presence of iron in the anolyte.

A.A. Rode (16) points out that this form of iron compound is evidently the simplest and the least dependent on the pH of the medium and on the concentration of Ca. The complex nature of such organic iron compounds is also confirmed by the results of experiments in the passage of these solutions through ion-exchange resins (KB-4, KU-2, AV-16) and by analysis of newly formed (legumes) sod-podzolic soils and soloths.

The forms of fixed iron are of primary importance in the migration of iron through the soil profile.

In one experiment, for example, the authors filtered a solution containing 30 mg of FeO/l, including 11 mg/l of fixed FeO, through a sod horizon sample forming a 10-cm layer. After the filtration, 14 mg/l of total FeO and 8 mg/l of fixed FeO were found in the solution.

Thus the unstable forms of ionic iron cannot migrate through the soil, whereas the fixed iron passes through the soil in considerable quantities.

Under the conditions of excess moisture, various ferrous iron compounds are formed in the soil, including soluble organic iron complex forms. Such water-soluble ferrous iron compounds under the conditions of

Table 4

Comparison of the properties of natural solutions and synthetic ferric iron

No.	Properties investigated	Natural solution	Synthetic salt
		Iron, %[a]	
1	Tyndall effect	Present	Present
2	Particle charge by the cataphoresis method	-	+
3	Qualitative reaction for Fe+++ without acidification	None	None
4	Solubility in 0.001 N HCl	None	None
	" " 0.005 "	66.7	None
	" " 0.01 "	100	Trace
	" " 0.05 "	100	6.5
5	Filtered by suction through Berkefel'd candles	85	None
	" through Pukal candles	41.3	None
	" through parchment filter	12.74	None
6	Adsorbed in passing through:		
	10 cm layer, with suction	100	100
	activated carbon	58.33	100
	illuvial horizon	41.66	100
	sod horizon	33.33	100
	podzolic horizon	25.00	100
	amorphous SiO_2	0.00	100
7	Precipitation of iron with a ration of Fe_2O_3 to water-soluble humus from peat of:		
	1:3.14	None	100
	1:1.46	None	52
8	Precipitation of $Fe(OH)_3$ from natural solution obtained from soil with forest litter, with a 1:6.6 ratio of Fe_2O_3 to water-soluble humus	None during the course of one year	

---

[a] For the investigation, solutions were used with the following concentrations of Fe_2O_3 in mg/l: No. 4 - 15.84, No. 5 - 28.94, No. 6 - 33.52, Nos. 7-8 - 15.80.

available oxygen may become ferric. To obtain such compounds for further study of their properties, the following procedure was used: 500 g of soil from the sod horizon, taken from areas with temporary excess moisture and containing a large amount of ferrous iron, were placed in a container and treated for ten minutes with distilled water with continuous agitation in a stream of carbon dioxide. The suspension was then filtered through large folded filters. The filtrate was allowed to stand until no negative reaction for Fe++ (with α-α'-dipyridyl) was observed. The solutions thus obtained had the external appearance of the weak iron salt usually prepared in the laboratory. The properties of the natural and artificial solutions of ferric iron were compared. The artificial iron salt was prepared as described by Aarnio (1). The iron was determined by the titanometric method.

The data in Table 4 show that both solutions have colloidal properties, confirmed by the presence of the Tyndall effect. In regard to the other properties associated with iron the solutions are essentially different. The artificial solution is a simple physicochemical system consisting of colloids of identical composition, whereas the natural solution is a complex system containing not only iron compounds but also a number of other water-soluble substances.

The lower oxide compounds removed from the soil by means of carbonic acid extraction may be both water-soluble minerals and organic forms of bi-valent iron. Oxidized mineral forms, which are represented mainly by ferrous bicarbonates, produce mineral colloids of iron hydroxide, and oxidized organic forms produce organic-mineral compounds of the type of the complex organic iron compounds. The entire system has a negative charge. The transition from the lower to the higher oxide is accompanied by the formation of compounds with various degrees of dispersion, as manifested by their ability to pass through filters with pores of different diameters.

The largest quantity of iron compounds in

Table 5

Dynamics of the oxidation-reduction potential (rH_2) and ferrous iron
(FeO in mg 100 g dry soil, extract of 0.1 N H_2SO_4 averaged over three years, 1955-1957)

Place sample taken	Horizon and depth, cm	April		May		June		July-Aug.		Sept.		Oct.		Nov.	
		rH_2	FeO	rH_2	FeO	rH_2	FeO	rH_2	FeO	rH_2	FeO	rH_2	FeO	rH_2	FeO
Section 1 Dense birch forest. Soil strongly podzolized, fine clay loam on clay loam mantle.	A_0 0—4	20,5	21,4	29,0	27,0	28,8	3,6	29,3	2,12	27,0	5,7	27,1	4,6	27,8	6,0
	A_1 15—25	21,7	2,3	30,9	9,0	31,2	1,93	31,0	1,15	28,9	2,5	29,1	2,4	28,9	1,8
	B_1 45—55	24,2	0,27	32,2	3,2	32,1	1,4	32,7	0,5	29,9	1,5	32,1	0,13	31,6	2,1
Section 2 Moss forest. Soil gley podzol on clay loam.	A_0 0—4	25,1	21,0	29,0	36,5	30,5	12,1	30,8	—	28,5	8,4	28,8	9,5	30,1	5,5
	A_1 4—8	24,4	8,0	28,8	31,7	31,7	7,0	32,3	7,0	30,3	3,4	29,9	2,06	29,3	2,0
	A_2 15—25	29,2	0,55	31,9	32,5	32,5	1,1	32,5	0,7	32,2	0,35	29,9	0,35	29,5	0,7
	B_1 45—55	Waterlogged		32,0	30,1	33,1	0,41	32,7	0,5	33,2	0,13	32,7	0,27	31,4	1,5
Section 3 Dry meadow. Soil is sod-strongly podzolized gley fine clay loam on clay loam.	A_1 2—10	22,0	9,0	30,2	4,0	30,0	1,8	30,2	0,95	30,8	2,8	29,6	7,9	28,5	11,7
	A_2 15—25	26,0	14,0	31,0	0,4	32,1	1,5	31,7	0,40	32,0	2,3	30,2	13,8	30,7	1,6
	B_1 45—55	Waterlogged		32,6	0,54	33,8	0,42	33,7	0,45	32,7	0,3	31,9	11,0	32,2	3,35
Section 3-a Plowland. Soil sod-medium podzolized fine clay loam on clay loam.	Ap 0—3	24,2	5,8	31,5	0,9	32,1	0,5	31,0	0,55	30,1	0,56	30,5	0,45	30,5	0,46
	Ap 10—20	22,6	4,6	31,8	0,7	31,8	0,3	31,4	0,48	31,1	1,3	31,3	0,75	30,5	1,00
	A_2 25—35	23,2	5,0	31,5	1,25	31,5	0,25	31,0	0,38	30,5	0,32	31,3	1,7	30,6	0,43
	B_1 50—60	25,4	0,33	33,3	0,4	32,3	0,20	32,7	0,30	32,0	0,33	31,3	0,7	31,2	1,09

Note: Comma represents decimal point; A_p represents Aplowed.

the natural solution passes through the Berkefel'd filter candles (85%), about half the quantity through the Pukal' ultrafilter candles (41.5%), and a still smaller part of the iron compounds (12.7%) through the parchment filter in dialysis. This indicates the presence in the solution of finely dispersed or molecular solutions of organic iron complexes. The colloids in the artificial solution are entirely withheld by all the filters.

The ability of the iron in the natural solutions to pass easily into ionic form under weak acidification indicates that the oxidation of the ferrous forms of iron causes the formation of easily soluble forms of ferric iron such as the freshly deposited, strongly hydrated oxides and organic iron complexes. Table 4 shows that 0.005 N HCl reverts 66.7% of the iron in these compounds into ionic form, and with a 0.01 N HCl in the solution all the iron passes into the ionic form; only a very small amount (6.5%) of the iron in the artificial solution, however, is reverted into the ionic form with a 0.05 N HCl in the solution.

One of the important properties of the natural solutions is their very great stability. In the case of the ratios of iron to water-soluble humus examined (1:3.14 and 1:1.46) in the natural solutions there was no precipitation of iron, whereas in the synthetic salt, in the case of the first ratio the precipitation was complete and in the case of the second ratio quite large (52%). In working with the natural solutions a case was noted in which no iron was precipitated from the solution during a whole year.

The combination of all the properties of the natural solution (negative charge, high dispersion, high stability, etc.) is manifested in the ability of the iron compounds to pass through the soil in the form of similar solutions; this is shown by the data on the filtration of solutions through the various horizons of sod-podzolic soil (Table 5). On the basis of this information, one may acknowledge the possibility of the formation of mobile organic iron compounds wherever the conditions of anaerobiosis and biochemical reducing processes appear. The latter may be defined by the magnitude of the oxidation-reduction potential.

In studying the dynamic aspects of the oxidation-reduction processes under natural conditions, four permanent areas were chosen in the Krasnopolyana district (village of Belyy Rast) Moscow Oblast', where for three years systematic determinations were made throughout the soil profile of the oxidation-reduction potential, the mobile forms of ferrous and ferric iron, the mobile aluminum and the water-soluble organic matter. The results of the observations of the dynamics of rH_2 ferrous iron are given in Table 5.

Table 5 shows that the oxidation-reduction conditions in soils under various types of growth of seasonal nature. The lowest values of rH_2, indicating reducing conditions in the soil, are observed in the spring. The values of the oxidation-reduction potential reach their greatest magnitude in the summer, the absolute quantities indicating a predominance of oxidizing processes in the soil. In the autumn the magnitude of rH_2 again decreases somewhat. The clearest seasonal change in the oxidation-reduction potential appears in soil under forest. It must be noted that in all cases the magnitude of rH_2 increases downward through the soil profile, indicating an intensification of the oxidizing conditions in the lower horizons of the soil.

A similar regularity may be seen in the changes in the ferrous iron. The greatest amount is formed in spring under forest vegetation in the upper horizon of the soil -- i.e., during the period in which the lowest values of rH_2 are noted. With such interrelationships of rH_2 in the soil profile, the ferrous iron formed in the upper horizons, decreasing in amount as one moves to the lower horizons, may be oxidized and turned into the stable water-soluble organic iron complexes whose properties have been mentioned previously.

Thus the data from field and laboratory investigations show the possibility of the formation of mobile forms of iron during reducing processes under the conditions of temporary excess soil moisture. In their broadest aspect these processes take place in the soils of the taiga zone, where the iron (along with the H ion) is a hydromorphic element of the landscape (13). In the southern part of the forest-meadow zone the processes of iron migration are most clearly manifested only in the swampy moss forests.

In the steppe zone, the conditions for the migration of iron in the form of organic iron compounds are produced only in places where there is temporary excess moisture -- in steppe depressions, estuaries, and below fissures, where the formation of solonetz, soloths, solodized soils and the so-called depression podzolized soils are observed (22, 23).

CONCLUSIONS

1. In soils with temporary excess moisture, reducing processes appear during the spring that lead to the formation of ferrous iron.

2. The ferrous iron, reacting with water-soluble organic substances, forms complex

organic iron compounds. Upon later oxidation of the iron these compounds maintain a high stability and the ability of migrating through the soil.

3. There is a possibility of the formation of complex organic iron compounds under the conditions of the formation of podzolic and bog soils, as well as soloths, solonetz and depression podzolized soils.

Received July 28, 1958

BIBLIOGRAPHY

1. AARNIO, V. 1915. Precipitation of the higher oxides of iron and aluminum in the earthy and gravelly soils of Finland. Pochvovedeniye No. 2, 3.

2. ALEKSANDROVA, L. N. 1954. The nature and properties of the reaction products of humic acids and humates with sesquioxides. Pochvovedeniye No. 1.

3. ANTIPOV-KARATAYEV, I. N. 1937. Migration of iron in the form of organic iron compounds. Trudy konferentsii po genezisu rud zheleza, margantsa, i alyuminiya. Akad. Nauk. SSSR.

4. AFANAS'YEV, A. N. 1930. The field of anaerobic processes and processes taking place in bogs. Pochvovedeniye No. 6.

5. BERG, G. 1937. The geochemistry of ore mineral deposits, translated from the German. ONTI, Moscow and Leningrad.

6. VERIGINA, K. YE. 1953. Some characteristic features of the processes of gleization of soils. Trudy Pochv. in-ta im. V. V. Dokuchayeva Akad. Nauk SSSR, Vol. 41.

7. VIL'YAMS, V. R. 1926. Soil Science, Part 2. Gosizdat, Moscow and Leningrad.

8. VISHNYAKOV, A. I. and O. A. RABINOVICH. 1935. Effect of organic acids in the soil on the mobility of iron. Trudy LOVIUAA, No. 36.

9. VYSOTSKIY, G. N. 1905. Gley. Pochvovedeniye No. 4.

10. ZAVALISHIN, A A. 1928. Some observations on the recognition of soils with a close gley horizon. In the symposium dedicated to K. D. Glinka. Leningrad.

11. KRYUKOV, P. A. and G. N. AVSEYEVICH. 1933. The hydrolysis and oxidation-reduction potential of the ferric-ferrous system. Trudy LOVIUAA, No. 17.

12. NOZDRUNOVA, YE. M., M. N. RYTIKOVA and A. F. SHEMYAKINA. 1956. Dynamics of the mobile forms of sesquioxides and the oxidation-reduction potential in sod-podzolic soils. Doklady TSKhA, 1:26.

13. PEREL'MAN, A. I. 1955. Outlines of landscape geochemistry. Geografgiz.

14. PONOMAREVA, V. V. 1949. The reactions of fulvic acids with basic hydroxides. Pochvovedeniye No. 11.

15. PONOMAREVA, V. V. 1950. New information on the intensification of the process of podzol formation. Vestnik Mosk. Universiteta No. 7.

16. RODE, A. A. 1937. The process of podzol formation. Izd. Akad. Nauk SSSR, Moscow and Leningrad.

17. SIBIRTSEV, N. M. 1914. Soil Science. St. Petersburg.

18. TYURIN, I. V. 1944. The study of the process of podzol formation. Pochvovedeniye No. 10.

19. SHIDLOVSKAYA-OVCHINNIKOVA, V. S. 1953. Quantitative determination of the content of various forms of iron in natural waters. Doklady Akad. Nauk SSSR, 90:4.

20. YARKOV, S. P., YE. V. KULAKOV and I. S. KAURICHEV. 1950. The formation of ferrous iron and the characteristics of the phosphate conditions in sod-podzolic soils. Pochvovedeniye No. 8.

21. YARKOV, S. P. 1956. Seasonal changes in certain processes of soil formation. Pochvovedeniye No. 6.

22. YARKOV, S. P. 1954. The formation of podzolic soils. Izd. Akad. Nauk SSSR, Moscow.

23. YARKOV, S. P., I. S. KAURICHEV and N. P. PODDUBNYY. 1956. An attempt to study the genesis of solonetz and soloths. Izv. TSKhA, No. 2.

THE MINOR BIOLOGICAL CYCLE OF ASH ELEMENTS AND NITROGEN IN THE PROCESSES OF MEADOW-STEPPE AND STEPPE SOIL FORMATION[1]

N. I. BASILEVICH
V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

Increasing attention has recently been devoted to the study of the exchange of ash elements and nitrogen between vegetation and soil. Investigators have repeatedly stressed the specific nature of the biological cycle of these substances for each genetic soil group (4, 9, 11, 12, 13, 14, 23, 24, 25, 33, etc.)

Up to the present time, however, such data have been limited not only for the basic soil groups but even for the major biologic and climatic soil zones of the USSR; they are exceptionally meager in the case of steppe grass vegetation with chernozem soils. Only the fragmentary information in Afanas'yeva (3), Aydinyan (2), Remezov (24) and the present author's data for one point (4, 14) are available. Still less has been published on the dry steppe zones with chestnut soils. These circumstances have prompted work on these problems.

This article is based on materials on the steppe and meadow-steppe plant communities of Western Siberia. In the Altay region these included wormwood-feather grass-tipchak (Festuca sulcata) dry steppe vegetation on chestnut soils, grassy-tipchak-feather grass dry steppe vegetation on southern chernozems and dense grassy-tipchak-feather grass on ordinary chernozems. In the Novosibirsk Oblast' these included meadow grass steppe vegetation on leached chernozems (on the Priobsk plateau). In the center of the Barabin lowland they included meadow grassy steppe vegetation and steppe meadows on meadow-chernozem soils (with ground water at a depth of 3-4 m). In treating the materials the author used certain procedures suggested by Rodin (30).

BIO-MASSES

The total amount of dry bio-mass[2] (above and below the ground) in the communities examined varies from 100-250 cntr/ha[3] (with a minimum in the dry steppes); of this, the green part of the vegetation amounts to 14-80 cntr/ha (Table 1, Fig. 1). The figures cited refer to moist years and are thus maximum. Computation of the bio-masses for years with varying meteorological conditions has shown that in dry years there is a considerable decrease in the organic material above the ground, as compared to wet years; the subterranean organic materials remain at the same level or even increase somewhat. Kuzmina (15) indicates a productivity of about 20 cntr/ha of dry weight (in average years) for the Baraba meadow steppes. Considering that the grass was mowed at a height of 3-4 cm, the total organic material above the ground here amounts to as much as 25-30 cntr/ha. According to determinations by Bobritskaya (5), the productivity of steppe meadows and meadow steppes on meadow-chernozem soils (the author calls them leached chernozems) in Chelyabinsk Oblast', even in the dry year 1955, amounted to 40 and 20 cntr/ha, respectively. According to Afanas'yeva's data (3), the quantity of organic material above the ground in the meadow steppes of the Kursk Oblast' (the Strelets steppes) comes to 30-40 cntr/ha in average years. Shalyt (38) for the same meadow steppes quotes 22-32 and 152-197 cntr/ha of roots; for the grassy-tipchak-feather grass steppes on southern

---

[1] The work was done in the laboratory for the study of the genesis and melioration of saline soils, V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR, and presented as a report to the First Congress of Delegates of Soil Scientists, 1958.

[2] This concept takes into account only the organic mass of the higher plants in the herbaceous communities under consideration, based on the weights of the grass harvest and the root systems in the optimum growth period (June and July).

[3] According to data from Aydinyan (2), the total quantity of the bio-mass in the Kamennaya steppe (steppe meadows) may be as great as 370 cntr/ha, of which the green part makes up 150 cntr/ha.

Table 1

Several indices of the minor biological cycle of ash elements and nitrogen in meadow-steppe and steppe soil formation

Index	Meadow-steppe soil formation				Steppe soil formation		
	Sec. 157. Meadow-chernozem soil. Steppe meadow	Sec. 4. Weakly solonetz-like meadow-chernozem soil. Steppe meadow	Sec. 17. Weakly solonetz-like meadow-chernozem soil. Steppe meadow	Sec. 18. Leached chernozem. Grassy-grain meadow-steppe	Sec. 200. Typical chernozem. Rich grassy-tipchak feather grass steppe	Sec. 3. Southern chernozem. Grassy-tipchak-feather grass steppe	Sec. 64. Chestnut soil. Wormwood feather grass-tipchak steppe
	Novosibirsk Oblast'				Altay region		
	Mikhaylovskiy rayon	Kargatskiy rayon	Ubinskiy rayon	Ordynskiy rayon	Shupunovskiy rayon	Rodinskiy rayon	Slavgorodskiy rayon
Total dry organic mass, cntr/ha	250	190	113	230	246	210	98
Including:							
green assimilating part, cntr/ha	80	60	33	80	45	30	14
%	32	32	29	35	19	14	14
roots,[a] cntr/ha	170	130	80	150	201	180	84
%	68	68	71	65	81	86	86
Included in litter: cntr/ha	137	103	60	130	112	90	42
Fraction of whole organic mass, %	55	54	53	56	46	43	43
Including:							
green assimilating part, cntr/ha	80	60	33	80	35	30	14
Fraction of whole organic mass, %	58	58	55	62	40	33	33
roots, cntr/ha	57	43	27	50	67	60	28
Fraction of whole organic mass, %	42	42	45	38	60	67	67
Total N kg/ha	161	121	111	161	147	93	45
Green assimilating parts, kg/ha	104	81	75	107	65	42	16
Fraction of total N, %	65	67	68	66	44	45	35
Roots, kg/ha	57	40	36	54	82	51	29
Fraction of total N, %	35	33	32	34	56	55	65
Average content of N in litter, %	1.18	1.20	1.80	1.24	1.04	1.03	1.06
Total ash, kg/ha	944	834	423	829	671	572	215
Green assimilating parts, kg/ha	603	537	262	557	224	172	100
Fraction of total ash, %	65	65	62	67	33	30	46
Roots, kg/ha	341	297	161	272	447	400	115
Fraction of total ash, %	35	35	38	33	67	70	54
Average ash content of litter, %	7.3	8.1	7.1	6.4	6.0	6.4	5.1
Litter/ash ratio	14:1	12:1	14:1	16:1	16:1	16:1	19:1
Total amt. Ca-K-P-S in ash, kg/ha	381	484	172	141	172	151	68
Fraction of total ash, %	40	58	41	17	26	26	31
Total amt. Ca-K-P-S in ash of green part, kg/ha	201	310	118	91	62	53	23
Fraction of total Ca-K-P-S, %	53	64	69	65	36	35	34
Total amt. of biohalogens (Na-Cl-excess S) kg/ha	10	55	11	26	14	12	6
Biohalogen fraction of total ash, %	1	7	3	3	2	3	3
Biohalogens in green part, kg/ha	9	47	9	22	10	8	2
Fraction of total biohalogens, %	90	85	82	85	72	67	33
Biohalogen fraction of litter, %	0.08	0.53	0.18	0.20	0.13	0.13	0.14
Total amt. of ash, kg-eq/ha	30.5	28.5	21.2	27.0	22.6	18.5	7.2
Excess of cations, in kg-eq/ha	9.4	10.3	2.9	1.8	3.9	3.5	0.9
Cation excess in green part, %	53	57	58	42	19	18	28

[a] The amount of roots is given for 0.5 m depth; this was determined by N.A. Kachinskiy's monolith method. The roots were washed in sieves with openings 0.25 mm in diameter; thus the root hairs were lost.

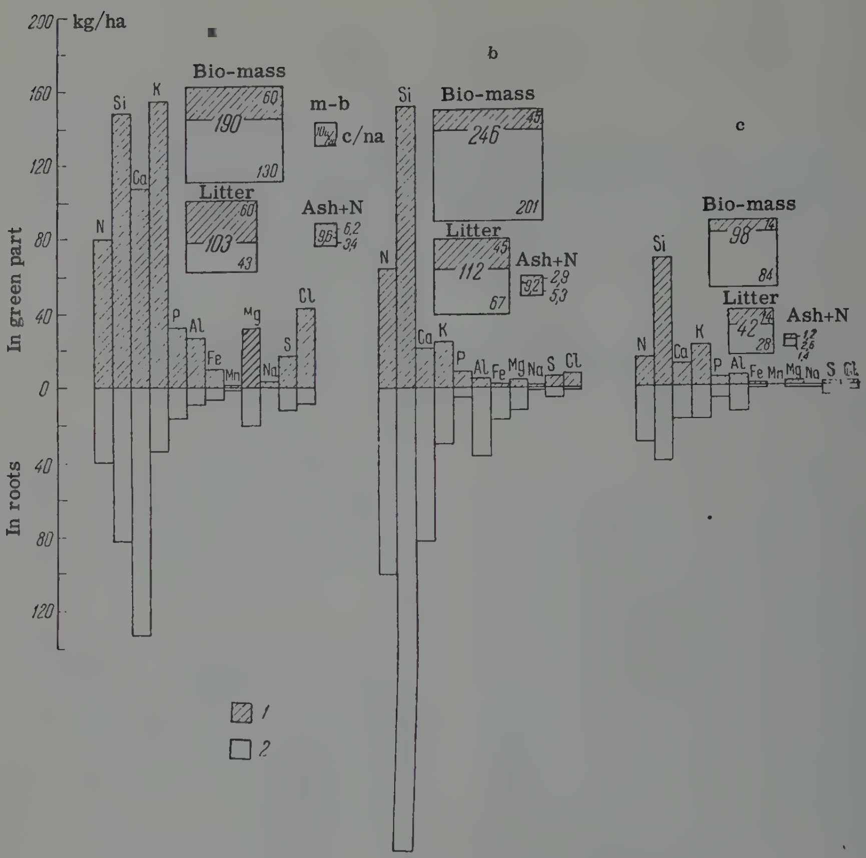


Fig. 1. - The relationship between the bio-masses above and below the ground, the annual litter and the annual amounts of ash and nitrogen in meadow-steppe communities on meadow-chernozem soils (Sec. 4), steppe communities on typical chernozems (Sec. 200) and dry steppe communities on chestnut soils (Sec. 64): a - Sec. 4; b - Sec. 200; c - Sec. 64; 1 - green part; 2 - root residues.

chernozems and dark chestnut soils (Askaniya-Nova) he cites 8-24 cntr/ha above the ground and 150-300 cntr/ha of roots; and for the dry steppes on chestnut soils (Prisivash'ye) up to 25 cntr/ha above the ground and 230 cntr/ha of roots. Lavrenko, Andreyev and Leont'yev (16), however, show a much lower productivity for the meadow, grassy-tipchak-feather grass and the dry steppes (15-10 and 5 cntr/ha, respectively). They used data on the Ukraine in 1935, disregarding more recent information.

The break-down of the bio-masses in the meadow-steppe (steppe meadows and meadow steppes) and steppe plant communities is different: in the first the quantity of green assimilating plant material constitutes 30-35% of the entire bio-mass, and in the second only 14-19%. The portion of roots changes correspondingly from 65-70% in the meadow-steppe communities to 80-86% in those of the steppes, where the soil is characterized by less total moisture and the root systems thus branch out farther. The more deficient the soil is in moisture, the greater is the proportion of roots in plant communities.

LITTER

Each year, the litter of leaves and dead roots constitutes more than half of the organic material that enters the soil -- 53-56% -- in the meadow-steppe community and no more than 40-45% in the steppe community.[4] The specific weight of the green part of the litter is higher in the meadow-steppe communities constituting more than half of the total weight of the litter -- 55-62%) and lower in the steppe communities (about a third -- 33-40%), with the minimum in the dry steppes. The proportion of dead roots, on the other hand, increases in the steppe communities and reaches a maximum in the subzone of arid and dry steppes (60-70% of the litter).

---

[4] For the method of computing the amount of the litter, see the paper by Basilevich (4).

ASH ELEMENTS AND NITROGEN

The ash and N contents liberated in the mineralization of the litter is determined by the chemical composition of the plant community and of the litter. In this regard, the relationship in the litter between the green part and the root residues is important.

The total ash contents in the above-ground part of the vegetation, both in the meadow-steppe and the steppe communities (shallow-rooted habitats) vary within the narrow limits of 4-10% of pure ash, with a predominance of 6-8% in the great majority of cases (Tables 2 and 3). Organogenic elements are preeminent in the ash composition.[5] The ash content is usually higher in the leafy plants. The ash content is somewhat lower in the roots than in the assimilating organs above-ground. The N content in the green part is also higher (1. 1-3. 5%) than in the roots (up to 1%).

Three basic groups may be distinguished among the grassy plants, each with a different relationship between the ash and the N content: 1) grasses and sedges, with a great predominance in the ash composition of SiO_2 -- 45-70%; K -- 10-30%; Ca -- 2-3%; the content of N is minimal -- 1. 1-1. 3% of the dry plant; 2) leguminous plants, typified by a considerable accumulation of K and Ca -- up to 30-40% of each in the ash; the N content is maximal, up to 3. 5% of the dry plant; and 3) herbaceous plants, which occupy an intermediate position between grasses and leguminous vegetation (Fig. 2a). The relationships of the ash composition in the roots are similar; in addition, a decrease in the proportion of K and increases in Ca and R_2O_3 are noted in the ash of the roots of all three groups.

The differences between these three groups of plants emerge still more clearly if the compositions of their ashes are recalculated without SiO_2 and R_2O_3 (taking substances, as suggested by V. A. Kovda, to be inert elements). In this case the content of ash elements in the grasses is expressed by the very small quantity of 1. 5-2. 0%; Ca makes up 6-15% of the ash; and K increases to 48-53%. In the legumes (and also herbaceous) the amount of ash elements without SiO_2 and R_2O_3 remains considerable, as much as 5-7%; the relative content of Ca now amounts to 30-40% and that of K to 30-50%. This clearly shows the importance of legumes in the formation of the soil structure.

The annual amount of nitrogen that enters the soil through mineralization of the litter and dead roots is directly proportional to the mass of the litter. This is greatest in steppe meadows and meadow steppes (120-160 kg/ha) and smallest in dry steppes (45 kg/ha). Almost 70% of the total nitrogen in meadow-steppe soil formation is produced through mineralization of the green part of the vegetation. In the steppes the chief role in the nitrogen accumulation is played by the root residues. The average nitrogen content in the litter (taking account of the part above-ground and the roots) is higher in the first group of communities (1. 2-1. 8%) and lower in the second (about 1%). The relative nitrogen enrichment of the litter in meadow-steppe soil formation is also due to the large role of leguminous and herbaceous plants in the phytocenosis.

The annual intake of ash elements is also a direct function of the litter mass. This is greatest in the meadow-steppe communities, reaching 800-1000 kg/ha,[6] and smallest in the dry steppe communities, where it is about 200 kg/ha (Fig. 1). In meadow-steppe soil formation the chief source of ash elements is in the green parts; in the steppes it is the root remains. The average ash content of the litter (including both green parts and roots) is therefore smallest in the case of dry steppe communities on chestnut soils, where it is 5. 1% in all; it is medium in the steppe communities, 6. 0-6. 4%, and highest in the steppe meadows on meadow-chernozem soils -- 7. 1-8. 1%. The latter is also associated with the noticeably greater leafiness of the green part and, consequently, the greater ash content in it. Moreover, the litter/ash ratio increases from 12:1 in meadow-steppe soil formation to 16:1 in the steppes and 19. 1 in the dry steppes. If SiO_2 and R_2O_3 are omitted from the total ash, it also appears that in meadow-steppe soil

---

[5] The organogenic group includes all the ash elements with the exception of Na, Cl and SO_3 (the latter in excess of 0. 3% of the dry plant, which corresponds to the greatest content of SO_3 in plants of non-saline habitats). The Na, Cl and excess SO_3 will here be called biohalogens. V. A. Kovda, stressing their toxic effect on plants, regards them as toxic salts (12, 13, 14).

[6] From R. Kh. Aydinyan's data (2) it follows, according to the present author's calculations, that these quantities may reach 1200 kg/ha. In order to compare the obtained quantities with those in the literature, all the recalculations are cited, based on the expression of the ash elements in the oxide formula. When recomputed in terms of elements, the annual intake of ash elements is about 400-500 kg/ha in the meadow-steppe communities and somewhat more than 100 kg/ha in the dry steppe communities.

Table 2

Ash composition and nitrogen content in plants of the meadow-steppe community (Baraba) given as percentages of pure ash (numerator) and of dry matter (denominator) (Analyses by A. G. Amchislavskaya)

Plants and fractions	N, %	Pure ash, %	SiO_2	CaO	K_2O	P_2O_5	Al_2O	Fe_2O_3	MnO	MgO	Na_2O	SO_3	C1	Ignited residue of water extract	HCO_3 Alkalinity % / mg-eq	$\frac{SiO_2}{R_2O_3}$
Poa pratensis	1,12	10,55	71,67 / 7,56	2,21 / 0,23	12,48 / 1,35	2,54 / 0,27	4.51 / 0,48	0,20 / 0,02	0,03 / 0,003	3.97 / 0,42	0,30 / 0,03	1,40 / 0,15	3,05 / 0,32	2,03	0,57 / 9,35	—
Calamagrostis epigeios	1,16	7,80	59,95 / 4,68	2,62 / 0,20	20,26 / 1,63	4,23 / 0,33	4,73 / 0,37	0.06 / 0,01	0,10 / 0,008	5,61 / 0,44	Not det.	2,22 / 0,17	10.06 / 0,79	2,95	0,43 / 7,02	—
Agropyrum repens	1,13	8.26	65,64 / 5,42	4,23 / 0,35	15,89 / 1,37	3,47 / 0,29	4,99 / 0,41	0,13 / 0,01	0,04 / 0,003	9,81 / 0,81	0,43 / 0,03	1,51 / 0,12	7,74 / 0,64	2,82	0,54 / 8,83	—
Filipendula haxapetala	1,13	9,76	35,40 / 3,46	18,94 / 1,85	24,22 / 2,40	4,69 / 0,46	8,94 / 0,87	0.06 / 0,01	0,12 / 0,01	12,70 / 1,24	0,42 / 0,04	1.44 / 0,14	7,35 / 0,72	4,67	1,18 / 19,40	—
Lathyrus pratensis	3,55	6,22	1,19 / 0,07	41,40 / 2,58	27,25 / 1,90	6,87 / 0.43	9,84 / 0,61	0,30 / 0,02	0,05 / 0,003	13.42 / 0,83	0,31 / 0,02	2,36 / 0,15	9,52 / 0,59	5,60	1,08 / 17,62	—
Grass cutting; meadow-grassy community with single steppe plants. Sec. 4	1,33	8,94	27,90 / 2,49	20,07 / 1,79	28,75 / 2,57	5,98 / 0,53	5.00 / 0,45	1,85 / 0,16	0,12 / 0,01	6,03 / 0,54	0,66 / 0,06	3,17 / 0,28	8,05 / 0,72	3,95	0.98 / 16,13	8
Roots	0,94	6,91	21,13 / 1,46	37,90 / 2,62	11,25 / 0,78	5,55 / 0,38	2,86 / 0,20	1,97 / 0,14	0,20 / 0,01	6,71 / 0,46	Trace	4,00 / 0,28	2,75 / 0,19	Not determined		9
Grass cutting; meadow-grassy community with some steppe plants. Sec. 14	2,28	7,95	52,05 / 4,14	11,84 / 0,94	23,65 / 1,89	4.47 / 0,36	1,46 / 0,12	0.07 / 0,01	0,04 / 0,003	4.42 / 0,35	»	5.00 / 0,40	2,01 / 0,16	»	»	56
Roots	1,32	5,96	48,58 / 2,90	16,93 / 1,01	8.74 / 0,52	5,50 / 0,33	6,29 / 0,57	2,98 / 0,18	0,05 / 0,003	2,99 / 0,18	»	3,94 / 0,23	1,68 / 0,10	»	»	10
Grass litter (ash soluble in 10% HCl). Sec. 14	0,93	10,47	61,08 / 6,40	11,07 / 1,16	2.50 / **0, 26**	2,59 / **0, 27**	6,84 / **0, 72**	4.03 / **0, 42**	Not det.*	5,65 / **0, 59**	0.13 / 0,01	2,05 / 0,21	0,33 / 0,04	0,77	0,33 / 5,36	11
Same (ash not soluble in 10% HCl).		5,65	64,73 / 3,66	4.86 / 0,27	Not determined		16,09 / 0,91	11.27 / 0,64	»	**2, 29** / 0,13	Not determined				—	5

Note: Comma represents decimal point.

Table 2 Continued

Plants and fractions	N, %	Pure ash, %	SiO_2	CaO	K_2O	P_2O_5	Al_2O	Fe_2O_3	MnO	MgO	Na_2O	SO_3	Cl	Ignited residue of water extract	HCO_3 Alkalinity % / mg-eq	$\frac{SiO_2}{R_2O_5}$
Same (total soluble and insoluble in 10% HCl)		16,12	62,40 10,06	8,87 1,43	1,61 0,26	1,67 0,27	10,11 1,63	6,58 1,06	Not det.	4,47 0,72	0,06 0,01	1,30 0,21	0,25 0,04	0,77	0,33 5,36	7
Strongly decomposed litter (ash soluble in 10% HCl). Sec. 14	3,16	14,12	50,76 7,17	11,09 1,57	2,42 0,34	2,34 0,33	14,17 2,00	8,21 1,16	»	5,30 0,75	0,23 0,03	1,65 0,23	0,94 0,13	0,64	0,27 4,39	4
Same (ash insoluble in 10% HCl)		19,28	72,36 15,11	1,01 0,19	Not det.		11,24 2,17	2,48 0,48	»	6,39 1,23	Not determined				--	10
Same (total soluble and insoluble in 10% HCl)		33,40	66,71 22,28	5,27 1,76	1,02 0,34	0,99 0,33	12,48 4,17	4,91 1,64	»	5,13 1,98	0,09 0,03	0,69 0,23	0,39 0,13	0,64	0,27 4,39	7
Grass cutting; meadow-grassy community. Sec. 157	1,30	7,54	52,00 3,92	13,83 0,79	18,24 1,37	3,09 0,23	2,34 0,18	0,25 0,02	»	4,43 0,33	0,47 0,03	1,71 0,13	1,11 0,08	2,70	1,00 16.40	34
Roots	1,00	5,98	27,15 1,62	34,85 2,08	8,95 0,53	5.17 0,31	7,98 0,48	3,25 0,19	»	5,23 0,31	0,35 0,02	4,00 0,24	0,07 0,004	1,86	0,82 13,41	5
Grass litter (ash soluble in 10% HCl). Sec. 157	1,19	8,41	55,01 4,63	11,20 0,94	13,00 1,09	4,76 0,40	3,30 0,28	0,09 0,01	»	5,19 0,44	0,52 0,04	2,89 0,24	0,26 0,02	0,62	0,36 5,90	28
Strongly decomposed grass litter (ash soluble in 10% HCl). Sec. 157	1,32	13,46	47,32 6,37	12,46 1,72	2,20 0,30	1,92 0,26	13,28 1,79	8,75 1,18	»	2,90 0,39	0,31 0,04	1,65 0,22	0,54 0,07	0,39	0,38 6.23	4
Same (ash insoluble in 10% HCl)	—	24,41	74,37 18,00	0,62 1,51	Not det.		15,96 3,90	2,78 0,68	»	0,40 0,10	Not determined			—	—	7
Same (total soluble and insoluble in 10% HCl)		37,87	64.33 24,37	8,53 3,23	0,79 0,30	0,69 0,26	15,02 5,69	4,91 1,86	»	1,29 0,49	0,11 0,04	0,58 0,22	0,18 0,07	—	—	6

Note: Comma represents decimal point.

Table 3

Ash composition and nitrogen content in steppe plants (Barbara and Kulunda) as percentages of pure ash (numerator) and of dry matter (denominator) (Analyses by R. A. Kalashnikova)

Plants and fractions	N, %	Pure ash, %	SiO_2	CaO	K_2O	P_2O_5	Al_2O_3	Fe_2O_3	MgO	Na_2O	SO_3	Cl	Ignited residue of water extract	HCO_3 Alkalinity $\frac{\%}{\text{mg-eq}}$	$\frac{SiO_2}{R_2O_3}$
Stipa capillata	1,17	3,44	45,67	3,86	31,25	5,80	0,98	0,27	3,11	0,17	2,37	11,07	1,74	0,18	—
			1,57	0,13	1,07	0,20	0,03	0,01	0,11	0,01	0,08	0,42		2,90	
Festuca sulcata	1,27	7,99	65,71	3,01	8,65	3,82	1,63	0,55	1,90	0,19	0,96	1,59	1,50	1,10	—
			5,25	0,24	0,69	0,31	0,13	0,04	0,15	0,01	0,08	0,13		18,03	
Thymus Marshalianum	2,69	7,89	7,12	23,84	40,12	9,27	6,26	1,13	3,75	0,47	3,03	Not determined			—
			0,56	1,88	3,17	0,73	0,49	0,09	0,30	0,04	0,24				
Medicago falcata	3,05	5,68	2,33	32,30	40,34	8.06	4,16	0,32	5,10	Trace	4,10	3,37	»	»	—
			0,13	1,84	2,29	0,46	0,24	0,02	0,29		0,23	0,21			
Artemisia austriaca	1,54	5,01	12,76	19,01	33,52	7,15	1,25	0,18	4,99	0,43	4,87	3,13	0,44	0,33	—
			0,64	0,95	1,68	0,36	0,06	0,01	0,25	0,02	0,24	0,16		5,36	
Grass cutting; grassy-grain meadow-steppe. Sec. 18	1,34	5,96	68,39	2,82	17,53	3,66	4,10	0,98	2,69	0,15	1,32	4,51	1,50	0,22	—
			4,08	0,17	0,67	0,22	0,24	0,06	0,16	0,01	0,08	0,27		3,54	
Roots	1,08	5,45	70,75	7,86	5,05	2,90	14,13	2,77	3,65	0,54	2,28	0,68	0,67	0,43	—
			3,86	0,43	0,28	0,16	0,77	0,15	0,20	0,03	0,12	0,04		7,05	
Grass litter. Sec. 18	1,22	8,66	65,67	7,53	2,83	2,47	10,61	4,56	3,29	1,33	6,30	0,58	0,53	0,24	—
			5,69	0,65	0,25	0,21	0,92	0,40	0,29	0,11	0,56	0,05		3,87	
Grass cutting; dense grassy-tipchak-feather grass steppe. Sec. 200	1,44	4,98	67,57	9,42	11,26	4,17	2,44	0,86	1,64	0,72	2,57	3,64	1,20	0,45	$\boxed{39}$
			3,36	0,47	0,56	0,21	0,12	0,04	0,08	0,04	0,13	0,18		7,37	
Roots	0,85	6,67	52,14	14.45	7,23	1,41	8,60	3,96	2,90	0,38	1,46	0,51	0,64	0,42	8
			3,48	0,96	0,48	0,09	0,57	0,26	0,19	0,03	0,10	0,03		6,88	
Grass litter. Sec. 200	1,18	5,44	64,34	14,28	3,32	2,22	8,66	4,95	2,93	0.27	1,40	2,06	0,21	0,26	$\boxed{9}$
			3,50	0,78	0,18	0,12	0,47	0,27	0,16	0,02	0,08	0,11		4,21	

Note: Comma represents decimal point.

Table 3 Continued

Plants and fractions	N, %	Pure ash, %	SiO_2	CaO	K_2O	P_2O_5	Al_2O_3	Fe_2O_3	MgO	Na_2O	SO_3	Cl	Ignited residue of water extract	HCO_3 Alkalinity % / mg-eq	$\frac{SiO_2}{R_2O_3}$
Old grass litter (ash soluble in 10% HCl). Sec. 200	1,82	12,04	48,97 5,90	13,50 1,63	2,33 0,28	1,72 0,20	15,53 1,87	8,80 1,06	13,96 1,68	0,48 0,06	0.53 0,06	0,63 0,08	0,23	0,23 3,79	4
Same (ash insoluble in 10% HCl)	—	16,70	71,99 12,26	0,50 0,09	Not determined		16,00 2,72	2,66 0,45	0,43 0,07	Not determined			—	—	7
Same (total soluble and insoluble in 10% HCl)	—	28,74	63,16 18,16	5,96 1,72	1,00 0,28	0,71 0,20	15,97 4,59	5,26 1,51	6,11 1,75	0.22 0,06	0.22 0,06	0.28 0,08	—	—	6
Grass cutting; wormwood-feather grass-tipchak steppe. Sec. 64	1,17	7,14	68,18 4,87	5,73 0,41	10.14 0,72	4,50 0,32	5,36 0,38	0,96 0,07	1,90 0,14	Trace	1,65 0,12	1,50 0,11	1,74	0,57 9,42	19
Roots	1,03	4,10	35,95 1,47	14,80 0,61	14,81 0,61	5,09 0,21	12,42 0,51	0.97 0,04	0,94 0,04	1,47 0,06	5,28 0,22	2,20 0,09	1,50	0,47 7,68	5
Grass litter, Sec. 64	1,12	7,20	67,18 4,84	8,45 0,64	3.51 0,25	3,07 0,22	5,71 0,42	3,29 0,23	1,91 0,14	0,30 0,02	1.77 0,13	0,30 0,02	0,22	0,24 3,85	13
Old grass litter (ash soluble in 10% HCl). Sec. 64	1,19	12,23	64.32 7,87	9,13 1.12	2,44 0,30	2,07 0,25	9,54 1,17	5,33 0,65	2,09 0,26	0,37 0,05	0,54 0,07	0,46 0,06	0,25	0,24 3,85	8
Same (ash insoluble in 10% HCl)	—	10,77	75,52 7,57	0,72 0,07	Not determined		16.12 1,62	2,51 0.25	0,28 0,03	Not determined			—	—	7
Same (total soluble and insoluble in 10% HCl)	—	23,00	67,10 15,44	5.17 1,19	1,30 0,30	1,10 0,25	12,09 2,78	3.93 0,90	1,23 0,29	0.22 0,05	0.29 0,07	0,26 0,06	—	—	8

Note: Comma represents decimal point.

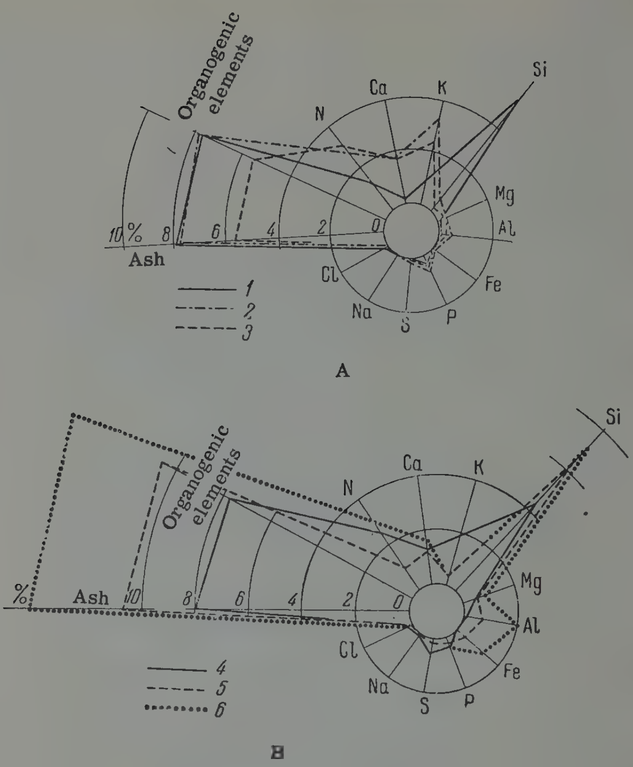


Fig. 2. - Ash composition and nitrogen content (as a % of the dry matter) in plants and steppe litter:

A, 1 - grass -- Festuca sulcata; 2 - herbaceous -- Thymus Marschalianum; 3 - leguminous -- Medicago falcata; B, 4 - harvest from steppe meadow; 5 - slightly decomposed steppe litter; 6 - strongly decomposed steppe litter.

Note: the symbols indicating the content of ash elements and nitrogen as percentages of the dry matter are plotted on coordinate axes radiating from the circle, which serves as the origin of the coordinates. The points are then connected to form rosettes.

formation the basic mass of chemical elements is produced by decomposition of the green parts, and in steppe soil formation by dissolution of the root residues. The average ash content of the litter (both above-ground and roots) will also be highest in the case of steppe meadows on meadow-chernozem soils -- more than 5.5%; it is much less for meadow-steppe communities on meadow-chernozem soils, where it comes to 3.3%.

In the case of meadow steppes on chernozems the average ash content of the litter is still lower; 2.3%, it is lowest in the herbaceous-tipchak-feather grass and dry steppes, where it is about 2.0%.

The main organogenic elements -- Ca, K, P, S.[7] The qualitative ash composition taken into the soil under various plant communities also differs noticeably. The accumulation of such important organogenic elements as Ca, K, P, and S is much greater in the steppe meadows -- up to 40-58% of the total ash; in the steppes the content of Ca, K, P, and S does not exceed 17-31% of the ash.[8] Meadow grassy steppes turn out to be closer to typical steppes in this respect, because of the considerable proportion of grasses in their herbaceous vegetation; grasses are distinguished for their small accumulations of Ca and K as well as P and S. This is one of the main criteria by which one may distinguish the biogeocenosis of steppe meadows on meadow-chernozem soils from that of meadow steppes on leached chernozems. In regard to the importance of the green part in the total amount of Ca, K, P and S liberated through mineralization of the litter, the meadow steppe communities again belong to a single group with those of the steppe meadows, in contrast to the steppes proper.

---

[7] Only the "organogenic" S is taken into account here; the "biohalogenic" S, if any, is considered in the overall balance of biohalogens.

[8] The exact figures for these groups of plants were determined by Kovda (14).

In meadow-steppe biogeocenosis up to 70% (53-69%) of the total Ca, K, P and S comes from the litter of the green part of the plants; in the steppes the chief source of the main organogenic elements is the mineralized root residues.

The biohalogens Na and Cl and surplus S. The accumulation of biohalogens in the group of plant communities considered here is very small, both in the ash (1-3%) and in the litter as a whole (under 0.2%). The quantity of biohalogens taken in is directly related to the mass of the litter (both above-ground and roots), but the biohalogens enter the soil mainly through decomposition of the green part. Their role in the meadow-steppe communities, however, is greater, the green parts here contributing 82-90% of all the biohalogens; in the steppes they contribute 67-72% and in the dry steppes only 33% of the biohalogens.

Thus the exchange of ash and nitrogen is governed, in regard to all the indices, primarily by the litter of the green parts in meadow-steppe soil formation and of root residues in steppe soil formation. In the steppes the roots are the main factor in the fertility of the soil.

The chief source of nutrients is formed by their decomposition and mineralization in the soil.

TRANSFORMATION OF SUBSTANCES

There are numerous indications of the nature of the transformation of substances and the trends of the soil forming processes under grass communities. In general, these amount to the following: the characteristic accumulation of humus substances, the formation of new humus with a predominance of humic acids, the formation of a thick organic-mineral colloidal complex saturated (or almost completely saturated) with cations, mainly Ca; the formation of soil under the conditions of a medium approaching neutrality, which is secured by the migration of carbonates in the stratum inhabited by roots; and the lack of dissociation and displacement of the mineral part.

Attempts have been made in the last decade to find the mechanism of these processes. Polynov's ideas (20) on the biogenic origin of the clay minerals in the soil produced synthetically from the final decomposition products of the litter[9] have turned out to be very fruitful in this regard.

These ideas were developed through study of various soils both by B. B. Polynov's students (1, 2, 7, 19, 40, 41, 42, etc.) and by other investigators (4, 6, 14, 24).

In order to follow the stages in the transformation of the mineral part of the plants of these communities, the present author, in sampling the grass crop, also made a parallel collection of the "steppe litter" in various stages of decomposition.[10]

In the mineralization of litter (Tables 2 and 3, Fig. 2b) one may observe an increase in the total ash content, SiO_2, R_2O_3, Ca and Mg, and a decrease in K, P, Na, Cl and N (the latter only in the early decomposition stages of the litter; later there is an increase in N which is probably due to an accumulation of dead microorganisms that took part in the digestion of the litter). The transformation of the litter in this direction is much more intensive in meadow-steppe and steppe soil formation (on chernozems) than in dry steppe conditions on chestnut soils. The molecular ratio of SiO_2: R_2O_3 changes from 34-56:1 in living plants to 9-11:1 in the litter and to 4:1 in strongly decayed litter -- i. e., it approaches these ratios in the secondary clay minerals of the montmorillonite group. This may be indirect evidence of the known participation of the chemical elements and compounds liberated by mineralization of the litter in the processes of clay formation.[11] In the dry steppes the range of these molecular ratios is considerably narrower. In this case there is a smaller tendency toward the formation of montmorillonitic clay minerals.

---

[9] The possibility of the synthesis of clay minerals from ionic solutions of Si and Al under the conditions of low temperatures, normal pressure and an alkaline reaction was recently shown by Henin (43).

[10] All the specimens of steppe litter were cleaned of mechanical impurities and washed with alcohol. They were then examined under the microscope, along with the ash (after combustion) and the insoluble residue in HCl (the admixtures), by Ye. A. Yarilova. Thus the calculations are based only on "pure" material free of clear extraneous impurities and representing plant tissue in various degrees of decomposition and transformation.

[11] Similar relationships have been established by Aydinyan (2) for the steppe meadows of the Kamennaya steppe.

Ca is accumulated in the ash of the mineralization litter primarily in altered forms, while Mg is mainly associated in more stable combinations with the secondary silicates and aluminosilicates. Thus the accumulation of these elements is closely related to the energy of the synthesis of clay minerals and of the organic-mineral compounds possessing high adsorptive properties. Ressel (29) has noted that the formation of the montmorillonitic group of clay minerals is favored by the presence of a large quantity of bases.

In the transformation of the plant residues, the organic substance plays a very important role as one of the basic components of the organic-mineral colloidal complex being formed in the soil. It has been shown in numerous papers by Mattson and Koutler-Anderson (44, 45) that the greatest accumulation of the organic colloidal complex (of acidoids) from the litter decomposition takes place under alkaline conditions, sufficient available oxygen, medium moisture, without leaching of the decomposition products and with an abundance of albuminous nitrogen and bases. Conditions close to the foregoing are created by the mineralization of the organic residues of the grass communities of steppe meadows, meadow steppes and steppes on chernozems. I. V. Tyurin has written that the transformation of the organic residues here tends toward humification, whereas in the dry steppes there is considerable mineralization (37).

The present author's calculations show that cations form the major part of the total annual deposition of ash elements. A part of these, mainly Al and to some extent Fe, are combined with the SiO_2 synthesized in the stable clay minerals. The remaining silica, which does not combine into secondary alumino- and ferrisilicates, is gradually metamorphosed into inert quartz. Yarilova (39) has determined the stages in the gradual crystallization of the opaline substance of phytolaria to biogenic quartz in the chernozem of the Kamennaya steppe. The crystallization of the phytolaria has been described by Parfenova for the podzolistic zone (19). This part of the silica requires no base in order to be neutralized.[12] A small portion of the cations is consumed in the formation of simple salts with Cl^-, PO_4^{---}, SO_4^{--}, etc. Most of them, however, which will be called excess cations, will evidently be combined with humic acids and partly with other organic substances of an acidic nature.[13]

The excess cations are, in general, directly related to the litter mass; however, it is mainly determined by the composition of the dead vegetation. In steppe meadows on meadow-chernozem soils, where the litter quantity is close to that of the meadow steppes and steppes, the excess of cations is much higher, often reaching 9-10 kg eq/ha; in the dry steppes the total is about 1 kg eq/ha (see Table 1). The major part of the excess cations in meadow-steppe soil formation comes from the green part of the litter; in steppe cenosis this comes from the mineralization of the root residues.

There is no doubt that these phenomena are associated with the greater intensity of the sod-forming process under a cover of meadow-steppe plant communities. In the uppermost, surface horizons of the soil the accumulation of mineral-organic compounds takes place at high rates and concentrations because of the large mass of the green part of the litter and the decomposition of the rhizomes occupying this layer, as well as the roots. In steppe soil formation, because of the leading role of the root residues in the formation of the organic-mineral colloids, the latter is more uniformly distributed through a greater thickness of the soil. The lack of uniformity in the course of these processes leads to differences in the structure of the humus profile of the soils, the absolute quantity of humus accumulation and its group composition, the soil structure, etc. The humus content in the surface horizons of meadow-chernozem soils reaches 15-18% and the exchange capacity 70-75 mg-eq. In chernozems these quantities are correspondingly lower. In connection with what has been said previously, it is appropriate to consider the question of the various forms taken by the sod-forming process and the role not only of the roots but also of the green parts in it.

MEADOW-STEPPE AND STEPPE SOIL FORMATION IN THE GENERAL SERIES OF SOIL-FORMING PROCESSES

A number of essential differences will appear from a comparison of the exchange of substances under grass communities of the steppes with those under forest and desert

---

[12] Part of the SiO_2 turns into the soluble form, acting as an anion in soil solutions and ground waters. Assuming that the average SiO_2 content in the waters of the humid zones in these latitudes is 30-40 mg, up to 2 kg-eq/ha of cations would be required to combine with this into salts. In the steppes these amounts are considerably lower.

[13] Attempts at similar calculations, although of a somewhat different nature, have been made by Ponomareva (22).

Table 4

Several indices of the minor biological cycle of ash and nitrogen in forest, steppe and desert biogeocenoses

Biogeocenoses	Biomass, cntr/ha	Green part of biomass	Root part of biomass	Litter		Ash and N kg/ha	Average N content in litter, aboveground and roots	Average ash content in litter, aboveground and roots	Litter/ash ratio	Ca+K+P+S in ash, %	Biohalogens in ash, %	Excess cations, kg-eq/ha	Principal elements added
				In biomass	cntr/ha								
		%	%	%			%	%					
Conifer forests on sod-podzolic soils	1000—3800	6—2	30—15	4—1	15—200	40—300	0,35	1,7—0,7	92:1	60—85	0,5	0,3—3,7	$\mathrm{Ca > N > \substack{K \\ Si}}$
Broadleaf forests on gray forest soils	1000—5000	4—2	40—15	7—4	20—300	150—700	1—0,4	7,5—1,6	33:1	70—90	1	2,2—10,9	$\mathrm{Ca > \substack{N \\ K \\ Si} > \substack{P \\ S}}$
Steppe meadows and meadow steppes on meadow-chernozem soils	115—320	30—35	65—70	50—55	100—180	550—1400	1,4	7,5	14:1	40—58	1—7	2,9—10,3	$\mathrm{Si > \substack{N \\ Ca \\ K}}$
Meadow steppes on typical leached chernozems	210—250	20—35	65—80	50—55	100—130	900—1000	1,25	6,8	15:1	20—30	2	1,8—4,2	$\mathrm{Si > N > Ca > \substack{K \\ Al}}$
Grassy-tipchak-feather grass steppes on ordinary and southern chernozems	200—300	10—20	80—90	40—45	100	600—1000	1,04	6,2	16:1	20—25	3	1,6—3,9	$\mathrm{St > N > Ca > \substack{K \\ Al}}$
Dry wormwood-feather grass-tipchak steppes on chestnut soils	100—180	5—15	85—95	35—45	40—50	200—250	1,06	5,1	19:1	30	3	0,9	$\mathrm{Si > N > K > Ca}$
Ephemeral-wormwood deserts on light sierozems	110—140	10—20	80—90	60—85	60—100	470—750	1,04	5,7	18:1	36—38	7—10	1,5—4,8	$\mathrm{Si > N > \substack{K \\ Ca} > \substack{P \\ Mg}}$
Semi-shrub halophyte-wormwood desert on gray-brown soils	40—50	2—3	85—90	25—30	8—10	75—90	1,53	5,1	20:1	57	22	1,0	$\mathrm{Ca > N > K > Na}$

Note: Comma represents decimal point.

communities[14] (Table 4, Fig. 3).

The total quantity of the organic material concentrated in the above-ground and subterranean parts of the plants in the steppe and meadow-steppe communities is several times greater than in the desert, but tenths smaller than in forests. The predominance of roots in the organic material noticeably distinguishes these communities from those of the forest, and approaches the conditions of the desert. The specific weight of the green part is greatest in the meadow-steppe cenosis. In the grass communities, in contrast to those of the forest, the accumulations of the green part are in direct ratio to the accumulation of the total bio-mass.

In the annual litter a much greater part of the bio-mass is removed in grass communities (60% in the meadow steppes and steppe meadows, 40% in the steppes, up to 90% in the desert) than in the forests (1-7%). The total ash and nitrogen is in proportion to the mass of the litter; this ratio differs, however, for the different plant formations. The greatest ash content and nitrogen are observed in meadow steppes and steppe meadows, where they amount to 1400 kg/ha. Next in order are the steppes, where these amounts are 600-1000 kg/ha, and then the dry steppes with 200-250 kg/ha. The steppes overlap with the short-lived wormwood deserts (470-750 kg/ha). In the biocenosis of broadleaf forests these figures do not exceed 670 kg/ha,[15] even when there is a greater mass of litter than in the grass communities. In the coniferous forests the amount is still lower -- down to 300 kg/ha (the minimum is noted for pine forests). In typical biyurgun-wormwood semi-shrub deserts the minor biological cycle takes place within narrower limits: the annual addition of ash and nitrogen to the soil is no greater than 70-100 kg/ha.

The basis of these manifestations includes the plants' selective capacity for the absorption of chemical elements, the ratio between the green part and the roots in the litter and, finally, the climatic features of the broad zones and subzones -- and consequently also the moisture conditions in the soil; this determines the amount of nutrient intake from the minor biological into the major geological cycle.

The average ash content of the litter (both above-ground and root parts) increases from north to south, from 0.7-1.7% in the coniferous forests and 1.6-7.5%[16] in the deciduous forests to 7-8% in the meadow-steppe communities. Farther to the south one observes a certain decrease in the ash content of the litter (this is due in the steppes and especially the dry steppes to the smaller leafiness of the vegetation and the greater portion of root residues in the mass of the litter, and in the desert plant communities in addition to the appearance of plants with lignified organs above and below the ground). Both these and others, as shown in a number of papers by the present author and Rodin (31, 32), are characterized by very small ash contents. It is typical, however, that the content of biohalogens in the litter ash of the desert communities (above and below ground) amounts to 20-24%, whereas in the steppe and meadow-steppe communities, with an equal or even greater average amount of ash in the litter (above and below ground together) this totals only 2-3% (excluding certain communities of the steppe meadows growing over nearby weakly-mineralized ground waters, for which see above).

The smallest content of biohalogens is in the litter ash of the forests. A number of papers by Kovda (13, 14) have also stressed the special role of biohalogens in the composition of the ash in desert vegetation.

The average nitrogen content (both above-ground and roots) is also lowest in the litter of coniferous forests and highest in the litter of meadow-steppe and typical desert semi-shrubs.

The main bearers of the most important organogenic elements -- Ca, K, P and S -- as well as of the excess cations, are the dead plants of the steppe meadows and the deciduous forests. These communities present the optimal conditions for the synthesis of secondary clay minerals, the formation of a great organic-mineral colloidal complex, and the manifestation of sod soil formation (a great mass of organic substances, a great content of organogens -- Ca, K, P and S -- and a large excess of cations in the litter, favorable moisture conditions to facililitate the processes of humification, a neutral or weakly alkaline reaction of the medium, etc.). South of the dry steppes and especially in the desert these conditions are less pronounced (partly because of the insufficient moisture and the displacement of the greatest intensity of the process to deeper horizons of the soil), as they are to the north in the taiga zone (because of the insufficient bases in the litter and the formation of non-neutralized humic and other organic acids in the decomposition of the plant residues).

---

[14] In the case of the forest communities the calculations were made from data in Remezov, Smirnova, Bykova, Dzens-Litovskaya, Mina and Zonn (8, 10, 17, 18, 24, 25, 26, 27, 28, 34, 35, 36); in the case of the deserts, from data of the present author and Rodin, both published and in manuscript form (4, 30, 31, 32).

[15] A certain dispersion of the points has been noted in Fig. 3 in the case of low values of the litter, indicating a young and more leafy plant.

[16] The greatest amounts for young plantations.

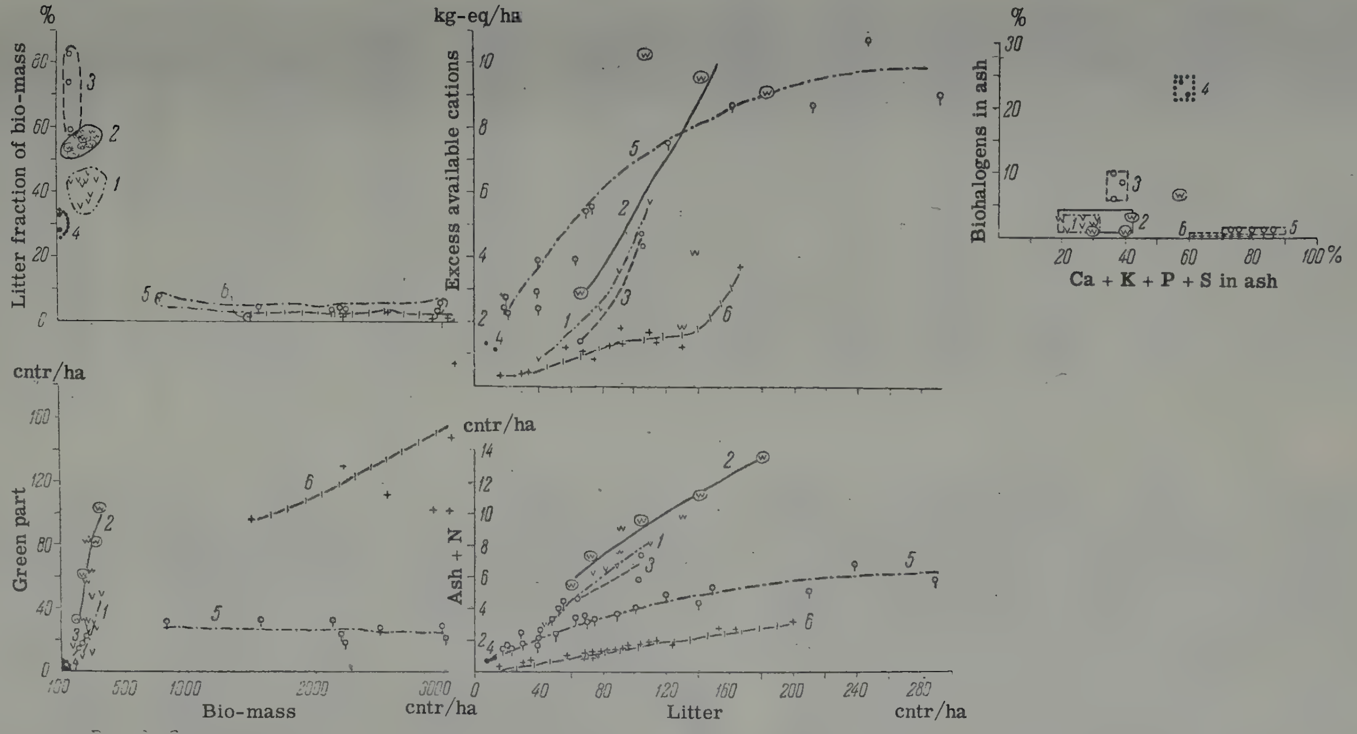


Fig. 3. - Relationships between the organic mass, the annual litter and the intake of nitrogen and ash elements in steppe, meadow-steppe, desert and forest soil formation:

1 - steppes on ordinary and southern chernozems and on chestnut soils; 2 - meadow steppes and steppe meadows on typical chernozems and leached meadow-chernozem soils (symbols for the latter are in small circles); 3 - ephemeral-wormwood deserts on light sierozems; 4 - halophyte-wormwood deserts on gray-brown soils; 5 - deciduous forests on gray forest soils; 6 - conifer forests on podzolic soils.

Thus, according to a number of features of the minor biological cycle of ash elements and nitrogen, five basic groups or types of biogeocenosis emerge: 1) grass, including steppe meadows, meadow-steppes, steppes and dry steppes; 2) the adjoining ephemeral-wormwood deserts; 3) deciduous forests; 4) conifer-moss forests; 5) typical semi-shrub deserts.

In regard to their biological cycles, the meadow-steppe and steppe biocenoses form a single closely related group. This is the basis for speaking of the common features of the soil formation under the grass vegetation of the northern zone, in the broadest sense of the word. Within this group the range of differences between the meadow-steppe and steppe communities according to their mineral exchange indices is comparatively small, and the differences are mainly quantitative. The ephemeral-wormwood deserts are to a certain degree removed from the biogeocenosis of the steppes; nevertheless both these and the others are sharply distinguished both from typical semi-shrub deserts and from the biogeocenosis of the forests. These peculiarities must definitely be taken into account in creating a genetic soil classification to support and help distinguish the main taxonomic soil groups.

CONCLUSIONS

1. Study of the interrelationships between the bio-mass (above and below the ground), the annual litter and the intake of ash elements and nitrogen in the meadow-steppe and steppe biogeocenosis (of Western Siberia) has shown that the exchange of ash elements and of nitrogen in the former is regulated mainly by the green part of the litter and in the latter by the root residues. The greater intensity of the sod forming process under the meadow-steppe communities is associated with these facts.

2. In the mineralization of the litter (in the steppe litter) the content of SiO_2, R_2O_3, Ca and Mg increases and that of K, Na, Cl, P and S decreases. The SiO_2:R_2O_3 ratio approaches 4, which is indirect evidence of the possible participation of the final products from plant-residue mineralization in the clay formation, along with the formation of the organic-mineral films surrounding the mineral particles.

3. The meadow-steppe and steppe meadow biogeocenoses, with respect to the exchange of elements, form a closely related group noticeably distinguished from those of the desert and the forest.

Received May 5, 1958

BIBLIOGRAPHY

1. AYDINYAN, R. KH. 1949. Exchange of elements and formation of mineral colloids in the first stages of soil formation on massive crystalline rocks. Doklady Akad. Nauk SSSR, 67:4.

2. AYDINYAN, R. KH. 1954. Ash composition of the meadow-steppe vegetation of the Kamennaya steppe and its effect on the formation of mineral colloids in the soil. Pochvovedeniye No. 3.

3. AFANAS'YEVA, YE. A. 1947. The origin, composition and properties of chernozems. Trudy Pochv. in-ta im. V.V. Dokuchayeva Akad. Nauk SSSR, Vol. 25.

4. BASILEVICH, N. L. 1955. Some features of ash elements in certain soil-vegetation zones of the USSR. Pochvovedeniye No. 4.

5. BOBRITSKAYA, M.A. 1958. The role of annual cultivated plants in the balance of organic and mineral substances in the soil. Pochvovedeniye No. 1.

6. BOLYSHEV, N.N. 1947. The genesis of the typical chernozems in the Priuyskaya part of the Western Siberian lowland. Pochvovedeniye No. 11.

7. GLAZOVSKAYA, M.A. 1956. The part played by plant ash in the formation of fine earths of weathering and soils. In the symposium: The weathered crust. Vyp. Akad. Nauk SSSR, 2.

8. DZENS-LITOVSKAYA, N.N. 1946. The ash composition of the forest vegetation in the Saval'skaya forest steppe. Pochvovedeniye No. 4.

9. ZAVALISHIN, A.A. 1955. The present state of the problem of soil systems and classification. Pochvovedeniye No. 4.

10. ZONN, S.V. 1954. The effect of forest on the soil. Izd. Akad. Nauk SSSR.

11. IVANOVA, YE. N. 1956. An attempt at a general soil classification. Pochvovedeniye No. 6.

12. KOVDA, V.A. 1937. Solonchaks and solonetzes. Akad. Nauk SSSR.

13. KOVDA, V.A. 1944. The biological cycles of ash migration and accumulation. Pochvovedeniye No. 4, 5.

14. KOVDA, V.A. 1956. Soil formation and the mineral composition of plants. Pochvovedeniye No. 1.

5. KUZ'MINA, M. S. 1953. The vegetation of Baraba. Trudy Pochv. in-ta im. V. V. Dokuchayeva Akad. Nauk SSSR, Vol. 36.

6. LAVRENKO, V. M., V. N. ANDREYEV and V. L. LEONT'YEV. 1955. The productivity profile of the above-ground part of the blanket of uncultivated vegetation of the USSR, from the tundras to the desert. Botan, zh., 60:3.

7. MINA, V. N. 1951. Ash exchange in oak forests on various soils. Trudy In-ta lesa Akad. Nauk SSSR, Vol. 7.

8. MINA, V. N. 1955. The cycle of nitrogen and ash elements in the deciduous forests of the forest steppe. Pochvovedeniye No. 6.

9. PARFENOVA, YE. I. 1949. Some secondary mineral formations in plants and soils. Probl. sov. pochvoved. sb. 15.

0. POLYNOV, B. B. 1945. The first stages of soil formation. Pochvovedeniye No. 7.

1. POLYNOV, B. B. 1948. The problem of the role of elements of the biosphere in the evolution of organisms. Pochvovedeniye No. 10.

2. PONOMAREVA, V. V. 1955. The problem of the role of vegetation in the formation of podzols. Pochvovedeniye No. 8.

3. PRASOLOV, L. I. 1937. A unified terminology and the basis for a genetic soil classification. Pochvovedeniye No. 3.

4. REMEZOV, N. P. 1953. The role of forests in soil formation. Pochvovedeniye No. 12.

5. REMEZOV, N. P. 1956. The role of the elements in the biological cycle in the formation of soil under a forest canopy. Pochvovedeniye No. 2.

6. REMEZOV, N. P., K. M. SMIRNOVA and L. N. BYKOVA. 1949. Some results of a study of the role of forest vegetation in soil formation. Vestnik MGU, No. 6.

7. REMEZOV, N. P. and L. N. BYKOVA. 1952. The requirements and the cycle of nutrients in oak forests. Vestnik MGU, No. 6.

8. REMEZOV, N. P. and L. N. BYKOVA. 1953. The requirements and cycle of nitrogen and ash elements in aspen forests. Pochvovedeniye No. 8.

9. RESSEL, E. 1955. Vegetation and soil.

30. RODIN, L. YE. 1958. The dynamic aspects of desert vegetation (from the example of Western Turkmenia). Avtoref. ha soisk. uch. stepeni d-ra biol. nauk. BIN Akad. Nauk SSSR, Leningrad.

31. RODIN, L. YE. and N. I. BASILEVICH. 1955. The cycle of ash elements and nitrogen in certain desert biogeocenoses. Botan. zh., No. 1.

32. RODIN, L. YE. and N. I. BASILEVICH. 1957. The minor biological cycle and the evolution of takyr landscapes. In the book: The takyrs of Western Turkmenia. Akad. Nauk SSSR.

33. ROZOV, N. N. 1956. The question of the principles in the construction of a genetic soil classification. Pochvovedeniye No. 6.

34. SMIRNOVA, K. M. 1951. The cycle of nitrogen and ash elements in a spruce-moss forest. Vestnik MGU, No. 3.

35. SMIRNOVA, K. M. 1951. The cycle of nitrogen and ash elements in mixed conifers. Vestnik MGU, No. 10.

36. SMIRNOVA, K. M. 1952. The requirements and the cycle of nutrients in basswood of the Mordovskiy national forest. Vestnik MGU, No. 6.

37. TYURIN, I. V. 1951. Some results of a comparative study of the humus content in the soils of the USSR. Trudy Pochv. in-ta im. V. V. Dokuchayeva Akad. Nauk SSSR, Vol. 38.

38. SHALYT, M. S. 1950. The underground part of certain meadow, steppe and desert plants and phytocenoses. Trudy Botan. in-ta Akad. Nauk SSSR, Ser. 3, No. 6.

39. YARILOVA, YE. A. 1952. The crystallization of phytolaria in the soil. Doklady Akad. Nauk SSSR, 83:6.

40. YARILOVA, YE. A. 1953. The mineral composition of the chernozems of the Kamennaya steppe and the effects on it of artificial forestation and the rotation of herbaceous crops. In the book: Problems of the grass system in agriculture, Vol. 2. Akad. Nauk SSSR.

41. YARILOVA, YE. A. 1956. The mineralogical investigation of a subalpine chernozem on andesite-basalt (in Armenia). In the symposium: The weathered crust. No. 2. Akad. Nauk SSSR.

42. YARILOVA, YE. A. and YE. I. PARFENOVA. 1957. The formation of new clay

minerals in soils. Pochvovedeniye No. 9.

43. HENIN, S. 1955. Nouveaux travaux consernant la synthese des mineraux argileux (In French). C. r. 5-me Congr. Int. Sci., Leopoldville, v. 11.

44. MATTSON, S. and E. KOUTLER-ANDERSON. 1941. The acid-base condition in vegetation, litter and humus. I. Acids, acidoids and base in relation to decomposition; III. Acidoid formation in relation to base status; IV. The strength of the acidoids and the relation to nitrogen. Reprinted from the Annals of the Agricultural College of Sweden. Vol. 9.

45. MATTSON, S. and E. KOUTLER-ANDERSON. 1954. IX. Acid and Base in decomposing litter. Ibid. Vol. 21.

PROBLEMS AND METHODS OF MICROSCOPIC AND MINERALOGIC SOIL INVESTIGATIONS[1]

YE. I. PARFENOVA and YE. A. YARILOVA
V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

In recent years interest has increased considerably in the mineralogic investigation of soils. Soil scientists have come to realize that studies of the soil genesis cannot succeed without mineralogical analyses, and that such analyses have a proper place among other methods of investigation. Application of these methods is still very limited, however, and often merely amounts to citing tables of minerals without sufficient interpretation.

Mineralogical investigations for the most part involve two methods, which are basically derived from petrography: study of soils in thin section and immersion analysis.

As regards the first method, in preparing thin sections the friable soil material is first boiled in various fixatives -- rosin, bakelite, etc. -- and then cut into thin sections as a solid material, down to thicknesses of 0.02-0.03 mm (2).

What can soil scientists learn from a study of thin sections? The chief merit of this so-called micromorphologic method is that it allows one to study the structure of microscopic soil particles without disturbing them and to observe many details that cannot be seen in studying the morphology of the soil section in the field. By studying thin sections one can obtain an idea of the minerals, both primary and newly formed, of their shapes and sizes and distribution through the soil profile, the structures of microscopic aggregates, pores in the soil, nature of the humus, etc.

The microphotographs in Figure 1 a, b and c show the appearance under the microscope of soils with coarse, medium and fine textures. The degree of rounding of the minerals in continental deposits is an indication of the duration of their transport; the rounding also frequently enables one to judge whether the minerals were transported by river currents (most rounded) or by glaciers (semi-rounded partially angular) (according to the various degrees of rounding, the presence of abrasion-marks, etc.). An angular shape is characteristic of minerals that have not undergone long transport.

Figure 2 shows microscopic aggregates in various soils. The chernozem soil of the Kursk national forest (Figure 2a) shows clearly segregated solid microscopic aggregates consisting mainly of clay materials cemented with calcium humates, and the winding interstices visible between them. In the gray forest soil of the Tula Oblast' (Fig. 2b), at a depth of 2 m, the dispersed clay material begins to be cemented together at the point where the carbonates appear in the profile. There is a peculiar structure in the subsolonetz, pseudo-sandy horizon of the Dzhanybek saline solonetz (Figure 2c), in which the clay loam material, in the presence of easily soluble salts, has been formed into aggregates about the size of sand particles.

In thin sections one may see various forms of organic matter from plant remains in various stages of decomposition to dispersed humus saturating the soil. Figure 3 shows a mobile form of humus in gray forest soils which has migrated through the soil profile with the clay material.

There is great variety in the forms of new materials; their study is of great value in interpreting processes that take place within the soil. Here the thin-section method is an irreplaceable aid to investigation. In thin sections prepared from samples throughout the depth of the soil profile one may observe the nature and the shapes of the newly formed minerals, their distribution in the soil, and the areas in which they are concentrated, and thus learn which new minerals are characteristic of which soils. Some of these have already been studied and will be described below in connection with the soils of various zones.

---

[1] Presented at the First Congress of Delegates of Soil Scientists, 1958.

There follows a brief discussion of the features of the second, or immersion, method.

The main task of immersion analysis is to determine the quantitative relationships between the minerals in the soil and to make a more thorough study of the individual mineral grains -- their shapes, optical properties and various alterations in soil formation.

In contrast to petrographic investigations, in which the chief attention is devoted to minerals down to 0.01 mm in diameter (and within these limits mainly to heavy minerals), the tasks of soil mineralogy are broader and require the study of minerals of all dimensions that form a part of the soil. Fractions greater than 0.25 mm in diameter are studied under a magnifying glass and in thin sections. The microscope is used to study fractions between 0.25 mm and $1\,\mu$; and a combination of special methods (X-ray, thermal, electron microscope and others) is used for smaller fractions. In soil investigations the different fractions are divided by their specific weight into two groups, heavy and light, as is done by geologists, and into 5-7 groups consisting of heavy minerals, micas, quartz, plagioclases, calcium-sodium felspars and light minerals, including many bioliths (such as phytolaria, whewellite, etc.), as well as organic-mineral and organic formations.

In spite of the rather widespread use of the immersion method, its application to soils still involves some large problems for discussion. The first problem is that of the preparation of the soil material for analysis; this cannot be the same for all soil types. Secondary soil formations such as humus, free iron hydroxides, manganese hydroxides, organic-mineral compounds (humus with sesquioxides and calcium humates), and microcrystalline carbonates cement together or form coatings around the primary minerals and make it difficult to study them. In order to determine and calculate the quantities of primary minerals, such coatings must be removed by treating the soil with hydrogen peroxide, hydrochloric acid, etc.; in this process the duration of the treatment and the reagents will be different for the different soil groups. The coatings themselves being products of soil formation must also be the objects of study. When similar newly formed minerals are present, the specimens must be studied in two ways: by destroying the new minerals and by preserving them.

Another difficulty is associated with the presence in the soil of microscopic aggregates (especially in chernozems) which must be broken up in order to free the primary minerals contained in them. There are, however, no strictly defined procedures for doing this. The single pulverization of the soil into a paste-like mass that is commonly used does not completely break up the aggregates, so that an accurate count of the amounts of the primary minerals is impossible under these conditions. But if the soil is dispersed by repeated pulverization, one may lose the integrity of the structure of both the primary minerals (especially those that have been somewhat altered) and the secondary ones and thus obtain a distorted picture of the natural condition of the mineral fraction of the soil.

The next problem is related to the quantitative determination of the minerals. In studying the two fractions (heavy and light), geology manuals recommend counting 400-500 grains in each fraction. In a more detailed subdivision into 5-7 fractions, each of which will contain a much smaller number of mineral species, one may count out only 200 grains in each fraction. It must be noted, however, that with a decrease in the grain size (fractions less than 0.01 mm in diameter, especially in the range between 0.005 and 0.001 mm) the counting of the grains becomes more complicated and the quantitative determination less accurate.

Immersion analysis, along with thin sectioning and other methods (mechanical and chemical) makes it possible to answer the important question of whether the deposits on which the soils are formed contain one or more components. The sources of such deposits may be judged by the composition of accessory minerals such as anatase, zircon, tourmaline, rutile, garnet, etc. The existence of many components is indicated by differences in the nature, quantity, sizes and shapes of the minerals through the soil profile. The most stable minerals are especially valuable in this respect. The most frequently encountered minerals in soils may be listed in increasing order of chemical stability: olivine, basic plagioclases, pyroxenes, amphiboles, biotite, intermediate plagioclases, acidic plagioclases, calcium-sodium felspars, epidote, muscovite, ore minerals (garnet, titanite, tourmaline, anatase, rutile, zircon and other accessory minerals), quartz. For the most accurate determination of the monomineralic nature of the rock and the soil, a comparison is made of the relationships between any two stable minerals from a single size-fraction at different depths.

Studies of specimens from great depths in drill holes often reveal organic remains, phytolitharia, polynite (7) and microscopic hard pans. Thus, for example, in the loess-like clay loam of the Kamennaya steppe the rock at a depth of about 6 m contains 0.02% of phytolitharia and 0.36% of organic remains (6). In the Tula Oblast', phytolitharia and organic remains are encountered at a depth of 11 m in the morainal deposits underlying the clay loam loess. Their presence may indicate either the existence here of a buried soil, or else that the composition of the deposits includes material from the upper horizons of the redeposited soils.

In studying the development of the soil forming process scientists in other countries have used mineral indicators (zircon, anatase, rutile, tourmaline, garnet, quartz, albite and microcline), by which they calculate, taking into account the bulk density, the loss or gain in this or that component of the soil in various horizons of the soil profile (8, 10). The alterations undergone by the primary minerals indicate the intensity of the soil forming process. This can be traced especially clearly in the minerals containing iron: discoloration, a decrease in the magnitude of the refractive index and a decrease in the particle density are all connected with the removal of iron. A large quantity of such altered minerals in the soil is an indication of intensified migration of the iron.

Among the primary minerals, important roles are played by the felspars and micas, which act as sources of nutrients, especially calcium, for plants and microorganisms. Many of the minerals that occur in the soil contain trace amounts of various other elements:

augite -- Ni, Co, Sc, Li, V, Zn, Pb, Cu, Ga;
apatite -- rare earths, Sr, Pb, F;
biotite -- Rb, Ba, Ni, Co, Sc, Li, V, Zn, Cu, Ga, F;
garnet -- Cr, Ga;
diopside -- Cr;
ilmenite -- Co, Ni, Cr, V;
cassiterite -- Sn;
magnetite -- Zn, Co, Ni, Cr, V;
muscovite -- F, Rb, Ba, Sr, Ga, V;
olivine -- Ni, Co, Li, Zn, Cu, Ga;
orthoclase -- Rb, Ba, Sr, Cu, Ga;
hornblende -- Ni, Co, Sc, Li, V, Zn, Cu, Ga;
staurolite -- Zn;
sphalerite -- Zn;
titanite -- rare earths, V, Sn, Cl;
tourmaline -- B, Li, F, Ga;
zircon -- Zr, Hf;
epidote -- Sr.

Immersion analysis is an aid in the study of the various salts and of the very important group of bioliths, which usually escapes the attention of mineralogists; the most widespread among these are phytolitharia and calcium oxalate crystals. It may easily be shown how the microscope helps bring greater precision into the study of the details in the decomposition of fresh plant litter that is being turned into underlying litter. One of the chemical analyses, for example, has shown that three times as much silica is accumulated in the litter as in freshly deposited litter, whereas the calcium oxide content decreases ten times. Under the microscope one can see that in the fresh litter the silica is mainly in the form of phytolitharia and the calcium in the form of oxalate crystals. The litter presents a different picture: the phytolitharia are maintained in it, but the calcium oxalate crystals are found in single units -- that is, one can see directly that in the underlying litter the silica is accumulated absolutely at the expense of the phytolitharia and relatively by means of solution and removal of the calcium oxalate. This calcium removed by the bioliths may ultimately take part in the formation of the calcite in the soil.

Immersion analysis and the study of thin sections have enabled us to proceed to an explanation of the complex question of the nature of the clay material in the soil known as polynite (Fig. 4). In our paper on "The formation of new clay minerals in the soil" (7) it was shown that polynite is distinguished by very similar optical properties, crystal lattice structure and chemical composition in soils of different zones. This homogeneous nature, as well as the fact that this substance appears in the very first stages of soil formation on massive crystalline rocks, suggests that it is of synthetic origin.

In the literature, especially that of other countries, the idea is often encountered that the clay material in the illuvial horizons of the so-called sols lessivés is formed not by means of synthesis, but by simple clay migration from the upper horizons into the lower (1, 9). Analysis of the picture presented by the distribution of clay in thin sections of various soils with an illuvial process leads to the conclusion that this cannot be explained merely by the clay migration. One can see segregations composed of alternating layers of colloidal and coarser material. The large pores are often filled with only one colloidmorphic substance, although if one were to entertain the idea of migration, it would appear that larger particles should also enter the pores. It is most probable that the process of illuviation involves both synthesized and migrated clay. Many more convincing proofs have appeared in support of the present authors' conclusion that polynite is synthetic, but much work still remains to be done before one can be satisfied that this is a final answer to the question. Above all, the process of formation and migration of the clay in soils must be reproduced and studied both in the laboratory and at soil stations in various zones.

Thus it appears that mineralogical analysis will not only bring much greater precision into existing concepts regarding the soil, but will also pose a number of questions, the answers to which will lead to important new conclusions that may often change the views held earlier. The micromorphologic method in particular, inasmuch as it does not demand much mineralogical training, should be more widely used by all soil scientists.

A description will be given of the newly formed materials in soils of various zones. The origin of the newly formed minerals is very closely associated with the ability of their chemical elements to migrate; this increases in regular succession from arid regions to moist ones, as B. B. Polynov has shown in his migration series. For example, the first to migrate are the rapidly removable compounds of Cl and SO_4, next the easily removable Ca-Na-Mg-K, then the mobile silica of the silicates, P and Mn, and finally there is a sharp increase in the mobility of even such inert elements as Fe and Al.

The soils of various natural zones are therefore characterized by specific newly formed materials. Within a single zone, these differ in soils of watersheds (eluvial conditions), bottomlands (excessively wet conditions) and the bottoms of impounded water (submerged conditions). The need for a unified approach to the investigation of the soils in such combinations of topography in the various zones has been insisted upon by Polynov in all of his theoretical and generalizing works. It is reflected in the underlying principles of his soil classification of 1933 (4). In a paper in honor of the thirty-fifth anniversary of the department of pedology of Moscow State University, V. A. Kovda again stressed the fact that the soils developed on these three types of surfaces must be classified in a single family.

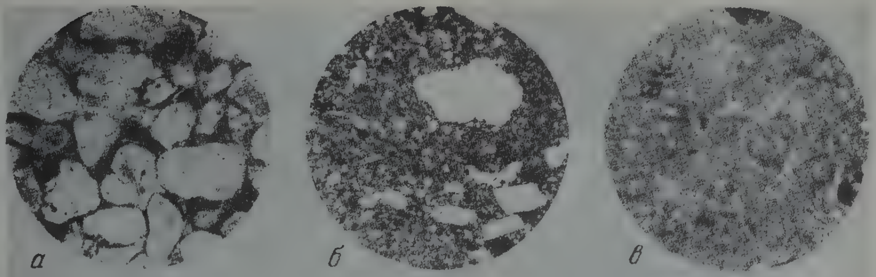
The following are some examples of newly formed materials, in terms of the scheme worked out by Polynov in characterizing the landscapes of certain natural zones.

1. In the dry steppe zone, with its high temperature and small amount of deposits, the compounds of Cl and SO_4 are mobile, but the capacity of the other elements to migrate is relatively low. Under the eluvial conditions of the sierozem soils the more mobile elements are therefore removed to a certain (not very great) depth, where there are conspicuous newly formed gypsum crystals built up into nodules (Fig. 5). Microcrystalline calcite is precipitated from the surface in rather plentiful amounts, since the calcium, which is not combined with the sulfate ion, migrates only slightly in these soils which are saturated with carbonic acid. There is a notable removal of the most mobile chlorides, along with the sulfates of monovalent cations, from the soils of the watersheds; these are accumulated in the excessively wet meadow soils (represented by various saline varieties all the way to solonchaks) being deposited in the surficial horizons in the form of halite (NaCl), bischofite ($MgCl_2 \cdot 6H_2O$), thenardite (Na_2SO_4), etc. The adjacent submerged soils of local closed bodies of water are represented by sapropel containing hydrogen sulfide and various salts. There are, however, no detailed studies of the formations at the bottom of the water.

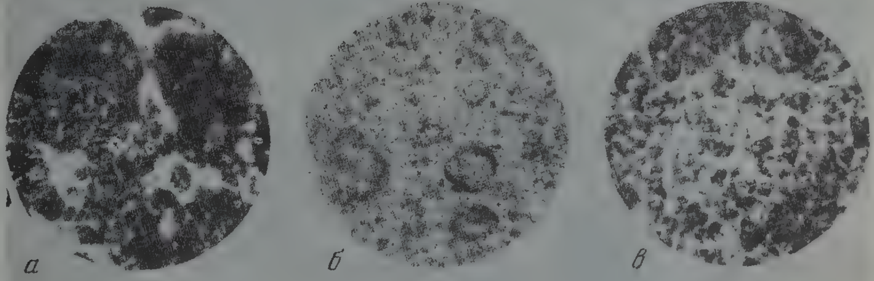
2. The chernozem soils of the watersheds are, for practical purposes, free of the easily soluble salts throughout the entire profile. The calcium in the uppermost horizons of such soils is combined with humus in solid clay aggregates, but since it is more mobile under these conditions than in the dry steppes, it is in part removed to the deeper horizons, where it is precipitated mainly in the form of microcrystalline calcite forming an illuvial horizon with respect to the carbonates. The microcrystalline calcite borders the pores and frequently fills them. Under favorable conditions (large pores, appropriate concentrations of bicarbonate in the solution and gradual vaporization), larger crystals are formed. Figure 6 shows calcite crystals of various sizes, directly adjacent to each other, in the chernozem of the Strelets steppe. The acicular form of calcite -- lublinite -- has also been observed here; this is evidence of differing conditions and of the fact that they were not formed at the same time. Under the microscope, the calcite may also be seen in disseminated form wherever the conditions are created for its precipitation out of the solutions into individual microscopic particles, and where it is not detected by its effervescence with hydrochloric acid. Whitefleck (Fig. 7) is formed by densely aggregated calcite crystals several microns in size. In addition to this, the carbonates in the soils include dolomite, aragonite, etc. Gypsum is deposited deeper than in the sierozems and in considerably smaller quantities. In this zone there is also an increase in the mobility of the silica, to judge by the very considerable accumulations of phytolitharia in the steppe grasses and by the presence of SiO_2 in the ground water. Besides this, secondary quartz crystals have been observed among the newly formed materials. Micro-ortsteins are formed in single units in the chernozems.

The lower horizons of the submerged soils, represented by meadow chernozems, contain large quantities of dense calcium concretions consisting of microcrystalline calcite cementing the clay loam. The local mineral-bearing ground waters play a role in their formation. The deposits at the submerged bottomlands here contain fresh-water marl.

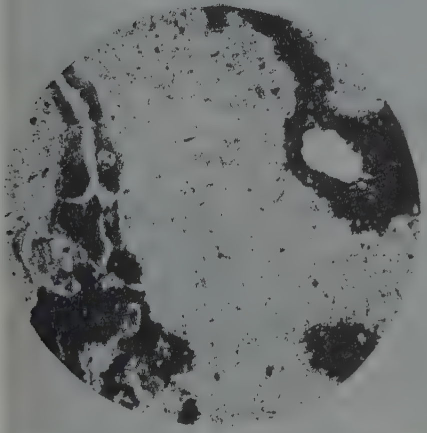
3. In the forest steppe, the gray forest soils of the watersheds are to a great degree deprived of calcium compounds. Microcrystalline calcite has been found at a depth of two or three meters, in very small quantities, in the form of tiny scattered concretions. Almost no gypsum occurs here. In these soils there begins to be a noticeable migration of the more inert elements -- SiO_2, iron and aluminum -- but this is mainly confined within the limits of



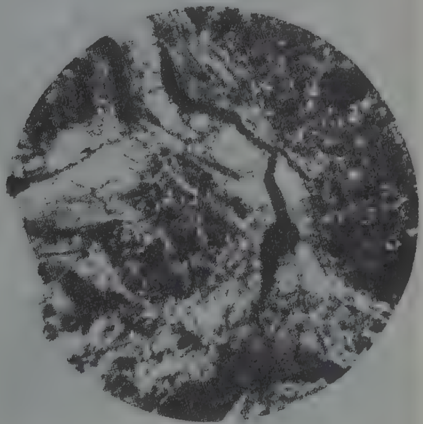
1



2



3



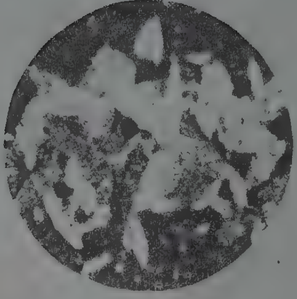
4

Fig. 1. - Microphotographs of soils with various textures:
a) coarse, b) medium, c) fine. Magnification x 100.

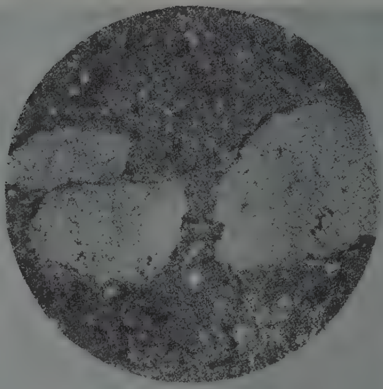
Fig. 2. - Micro-aggregates in soils:
a) chernozem from the Kursk national forest, b) gray forest soil from the Tula Oblast';
c) solonchak-like solonetz from the Dzhanybek soil station. Magnification x 100.

Fig. 3. - Mobile humus in gray forest soil.
Magnification x 100.

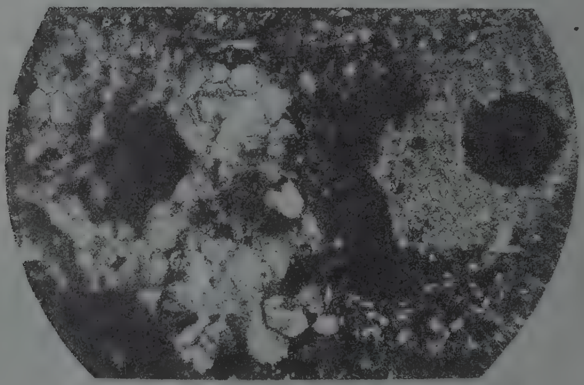
Fig. 4. - Conchoidal concretions of polynite.
Magnification x 360, nicols +.



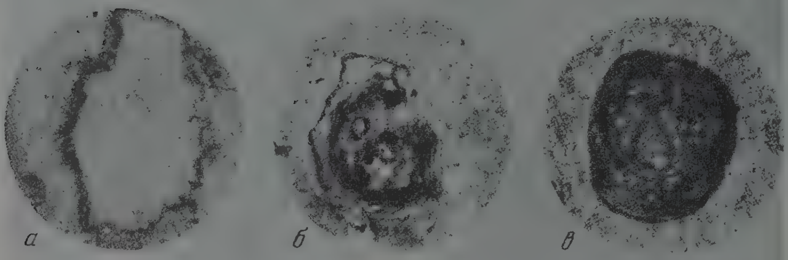
5



7



6



8

Fig. 5. - Gypsum in sierozem soil.
Magnification x 100, nicols +.

Fig. 6. - Compact nodules of microcrystalline calcite.
Magnification x 360, nicols +.

Fig. 7. - Large and small crystals of calcite surrounding pores.
Magnification x 360, nicols +.

Fig. 8. - Micro-ortsteins in soils:
a) diffusion ring, b) system of concentric diffusion rings,
Magnification x 360.

the soil profile. A special feature of the gray forest soils is polynite (4, 8), which is composed mainly of these elements and is deposited in the form of brownish-yellow conchoidal concretions in fissures and pores. This is encountered in small amounts at the surface and in noticeable concentrations in the well developed illuvial horizon (at a depth of 1.5-2 m) along with dark-colored humus.[2] Secondary quartz occurs quite often in these soils. Micro-ortstein like concretions (from 0.3 to 2-3 mm in diameter), consisting chiefly of iron oxides with some admixtures of humus and manganese, are formed in large quantities throughout the whole profile of these soils. Ortsteins in the soil are well known to all soil scientists, but the beginning and the different stages of their formation may be observed only through the microscope. Among the initial forms, one may see nodules of small amounts of iron hydroxides and humus in the form of thin, sinuous diffused rings (Fig. 8a). Concentric systems of such rings are sometimes formed (Fig. 8b). There are also solid concretions, varying in size from the hundredth part of a millimeter to 1-2 mm in diameter or compact or wide rounded or oval rings (Fig. 8c). These concretions include soil material, and a certain concentration of polynite has often been noted. The shapes of the micro-concretions vary greatly even in the same horizon; this is due to the variety of the conditions of their formation in individual parts of the soil, and more precisely to the different oxidizing-reducing conditions and microbiological activities and the varying amounts of migrating substances composing the ortstein.

In the gray meadow soils of this zone the segregations of scattered microscopic calcite are observed closer to the surface; in addition, dense, calcium concretions are present in significant amounts from a depth about 1 m. In these soils the humus concretions have a darker color, and the polynite accumulations are considerably enriched in humus. There are numerous micro-ortsteins.

4. Under the conditions of the podzolic zone the calcium migrates rapidly, so that neither the soils of watersheds nor those of bottomlands nor the deposits underlying them contain any calcite. In this zone the silica, iron and aluminum have still greater mobility and are taken into the ground waters in considerable quantities, along with humus. In the profile of the sod-podzolic soils these elements enter into the composition of the polynite, which here has a lighter color than in the gray forest soils and is confined to the illuvial horizon. As one moves northward the conditions become less and less favorable for the creation of stable compounds of silica with aluminum and iron, and the amount of polynite in the soil diminishes. Amorphous iron oxides here take part in the formation of the illuvial horizons of the podzolic soils of watersheds, and the illuvial horizons of the peaty-podzolic soils of the bottomlands also involve non-polar compounds of humus, mainly with aluminum. The calcined fraction of these formations contains more than 70% of Al_2O_3 (3). The ortsteins, both micro- and macroscopic, are very widespread in this zone. Secondary quartz, which if found in the soils of the sod-podzolic zone, has not been discovered in the more northern regions.

The deposits at the submerged bottomlands are rich in so-called pisolitic ores, which consist primarily of iron, aluminum and manganese. The literature (5, p. 482) indicates that these are accumulations of calcium carbonates in the older beds of the deposits at the submerged bottomlands in the podzolic zone; these evidently involve calcium removed earlier from the surrounding watersheds during the continuous soil formation process.

Only the most widespread newly formed materials have been considered here; these occur in much greater variety in the soils and include many species which have as yet not been studied at all.

The following remarks must be concluded. The trends of Soviet soil mineralogy are somewhat different from those abroad. In addition to the more usual investigations whose purpose is to study the primary minerals making up the soil, to determine the sources of the deposits and the numbers of their components and to find the forms of the substances that enter into the minerals, etc., Soviet efforts are also concerned with genetic problems associated with the effect of organisms on mineral formation and with determining the forms of new minerals that arise during the various soil formation processes. This article has shown that the origin of new compounds is very closely dependent on the ability of their component elements to migrate. Mineralogical investigations must therefore be made as a part of the combined study of vegetation, soils, natural waters and bottom deposits, in the light of Polynov's study of geochemical landscapes.

Received May 20, 1958

BIBLIOGRAPHY

1. MINASHINA, N. G. 1958. Optically oriented clays in soils. Pochvovedeniye No. 4.

2. MOCHALOVA, E. F. 1956. The preparation of soil thin sections without disturbing the structure. Pochvovedeniye No. 10.

---

[2] It is observed in small, very transparent masses in thin sections of specimens from depths down to 12 m.

3. PARFENOVA, YE. I. and YE. A. YARILOVA. 1956. The formation of secondary minerals in soils and plants in connection with the migration of elements. Doklady VI Mezhdunarod. kongr. pochvovedov, komissiya 2-aya, Moscow.

4. POLYNOV, B. B. 1933. Fundamental principles in the genetic classification of soils. In the symposium: Problems and methods of soil studies. Trudy sov. sekts. MAP, komissiya 5-aya, No. 1, Sel'khozgiz.

5. POLYNOV, B. B. 1956. Selected works. Izd. Akad. Nauk SSSR.

6. YARILOVA, Ye. A. 1953. The mineral composition of the chernozem of the Kamennaya steppe and the effect on it of artificial forestation and grass crop rotation. Problems of grass crop rotation in agriculture, Vol. II. Izd. Akad. Nauk SSSR.

7. YARILOVA, YE. A. and YE. I. PARFENOVA. 1957. The formation of new clay minerals in soils. Pochvovedeniye No. 9.

8. BARSHAD, J. 1955. Soil development. Chapter I of the book: Chemistry of the Soil, edited by Firman S. Bear. New York.

9. BREWER, R. and A. D. Holdane. 1957. Preliminary experiments in the development of clay orientation in soils. Soil Sci., 84:4.

10. MARSHALL, C. E. and J. F. HASEMAN. 1942. The quantitative evaluation of soil formation and development by heavy mineral studies; a. Grundy silt loam. Soil Sci. Soc. Amer. Proc., 7, 448-453.

OXYGEN CONTENT IN GROUND WATERS OF SOME FOREST SOIL GROUPS OF THE VOLOGDA OBLAST'

A. YA. ORLOV
Forest Soil Science Laboratory, Institute of Forests
Academy of Sciences, USSR

The oxygen content in ground waters was determined by studying the changes in the main soil factors in the principal forest types within the area of the Northern Forest experimental station, Institute of Forests, Academy of Sciences, USSR. This area, which is typical of the extensive territory of the northern part of the Vologda Oblast', has a flat, very weakly dissected topography. The soils are developed on fine clay loam carbonate moraine, which is covered only in elevated places by thin, coarser deposits. Moreover, soil formation throughout almost the whole territory of the region takes place under conditions of constant or intermittent excessive moisture in the upper soil horizons. A study of the changes in the oxygen content of the waters that saturate the soil strata (as one of the indications of the amount of oxygen obtained by the roots of the plants) is of very great importance here, since the oxygen behavior, which also affects the other factors in forest growth, determines the yield of forest vegetation.

Hesselman (8) had already discovered the relationship between forest growth and the oxygen content in the ground waters. Papers by Bystrov (1), Latysheva (4), Malyanov (5), Verner and Gordeyeva (3) and others present data on the oxygen content in ground and soil-ground waters and reveal a number of regular changes in the oxygen concentration during the vegetative period.

From the standpoint of the effect of oxygen behavior on the activity of plants, the paper by Malyanov (5), who determined the oxygen content in the waters filtering through the upper, root-bearing horizons of the soil stratum, is of great interest. His information shows that the oxygen concentration in the soil-ground waters changes sharply during the course of the vegetative period; frequent determinations are therefore needed in order to discover the dynamics of this process. Malyanov, along with Bystrov (1), notes an increase in the oxygen content in the autumn. Most authors point out that the oxygen content in the soil-ground waters affects the degree of soil humification. A large quantity of organic substances favors more rapid consumption of the oxygen.

The present author has sampled soil-ground waters from filters similar to those made by Latysheva (4). The filter was a closed brass tumbler with an outlet pipe. The water entered through numerous openings in the sides of the filter, which were enclosed in layers of copper-wire screen and gauze. The water was taken out in a 50-ml syringe through a thin pipe inserted into the filter's outlet pipe. By means of the syringe it was possible to obtain pure, small samples of water. In this process no vacuum was produced in the filter cavity, so that the successive portions of water entered the filter under normal pressure without carrying in any soil particles in suspension. The syringe's capability of taking small samples of water is also of great importance. When large volumes of water are sampled (as would be the case in removing the water with a pump through a system of flasks) the results of the determinations often turn out to be incorrect, since in the upper, friable horizons of the soil there is an influx of water not only from the sides but also from above. Before taking the samples, the water that filled the filter was first drawn off by suction (in compact, poorly filtering horizons that had to be done for several hours before the samples were taken). Observations have shown that the water that has been filling the filter for several days before the sampling contains a different amount of oxygen from the water that surrounds the filter.

The filters were set at depths of 15, 30 and 50 cm -- that is, within the layer of the soil inhabited by roots, whose thickness in most cases is no greater than 50 cm. Besides taking samples of water from the filters, many water samples were taken directly from the soil stratum by a syringe with a thick needle 30 cm long. This method, which was used only for the loose, mainly organogenic horizons, produces results which more accurately reflect the oxygen content in the water at a specific depth; because of its simplicity it also makes it possible to obtain a large number of repeated samplings at various points in the plot of ground. The oxygen content in the water samples was determined by Winkler's method.

The largest number of determinations was made in the widespread peat-humus gley soils that lie on the middle and lower parts of the very gentle slopes of low ridges and elevated areas. These soils are characterized by the presence, under the layer of forest litter of a peaty horizon 5-10 (20) cm thick which grades into a humus horizon with a humus content of 5-10%. At a depth of 35-45 cm this is underlain by a fine carbonate clay loam, which effervesces in 10% HCl at a depth of about 70 cm from the surface.

The following sample areas have been investigated: No. 5 -- a mature grass-moss fir stand of site quality IV; No. 1 -- a ten-year old birch stand that has grown up after cutting a coniferous forest; No. 2 -- twenty-year old birch stand; No. 8 -- recent cut-over area.

In the podzolic soils, the oxygen behavior was studied in two sample plots: No. 6 -- mature fir stand whortleberry mixed with birch of site quality III, and No. 7 -- twenty-year old birch stand.

The podzolic soils at the ridgetops are characterized by a thin, strongly podzolized coarse clay loam or sandy loam A_2 horizon. The B horizon, which is also clay or sandy loam, is underlain at a depth of 50 cm by a carbonate moraine.

In addition, observations were made in sample area No. 9 -- sedge-sphagnum mature fir stand mixed with birch on site quality V on peaty soil (with a peat layer about 130 cm thick), lying on a flat watershed.

During part of the period of vegetation in 1957, the oxygen content was also determined in a narrow zone of mature native fir stand on site quality II on peaty-gley clay soil.

Before the basic material is presented, the great lack of uniformity in the oxygen concentration in the soil-ground waters at different points of a single plot must be noted. The following data were obtained in 1957 for plot No. 5, at four points chosen for their similarity in micro-relief (relatively flat areas): at a depth of 20 cm, on July 2, the content was 1. 5, 1. 3, 1. 5 and 1. 4 mg 0_2/l of water; on July 10, the content was 2. 5, 1. 6, 2. 5 and 2. 4 mg/l; on Oct. 18, the content was 2. 0, 2. 4, 2. 8 and 2. 6 mg/l; at a depth of 30 cm, on April 23, the content was 2. 4, 2. 5, 1. 2 and 0. 9 mg/l; on July 2 the content was 1. 1, 0. 3, 1. 5 and 1. 2 mg/l; on July 10, the content was 0. 8, 1. 2, and 3. 2 mg/l; and on Oct. 18, the content was 1. 5, 0. 6, 2. 1 and 0. 8 mg/l. Only on individual dates, at the depth of 20 cm (for example, on July 2 and 10), did repeated determinations produce fairly close results. In the majority of cases, especially at the depth of 30 cm, the discrepancies were extremely great. One would of course scarcely expect close agreement under these conditions. The rainwater which is the chief source of oxygen for the soil stratum falls unequally over the surface of the soil depending on the presence of tree canopies; the infiltration of rainwater is also unequal. It may be assumed that the rate of oxygen consumption is different even through the same depth, since the soils of the taiga forests are characterized by a sharp lack of uniformity in the thickness, humus content, etc. of the genetic horizons. Finally, the surface of the water-stable fine clay loam, along which most of the water flows off laterally, is wavy with saucer-shaped depressions in which the water may be retained for long periods. The rate of diffusion of the oxygen in the water is known to be very low and thus cannot bring about a uniform concentration of oxygen in the waters of the soil stratum.

Thus even with several parallel determinations of the oxygen content, one must not count on obtaining sufficiently stable quantities. Nevertheless, because of the very sharp changes in the oxygen concentration during the period of vegetation (which is usually somewhat greater than the discrepancy between parallel determinations), the quantities obtained make it possible to trace the general features of the seasonal changes in the oxygen content, and to note differences in the oxygen content of the waters in various soil types.

Figures 1, 2, 3, and 4 show the change in the soil temperature at a depth of 30 cm, precipitation greater than 4 mm per day over open areas, the fluctuation in the groundwater level and the content of dissolved oxygen (the amounts of the oxygen content at various depths are indicated directly on the graphs) during the periods of vegetation in 1956 and 1957.

The change in the oxygen content of the ground waters will be traced in greater detail for one of the sample areas (No. 5), which has a fir stand growing on peat-humus gley soil (Fig. 1A). On the first date of observation, in the water samples taken below the frozen layer of the soil,[1] the oxygen content did not exceed 1 mg/l; in the meltwater filling the depressions

---

[1] The soil did not thaw at a depth of 5-15 cm.

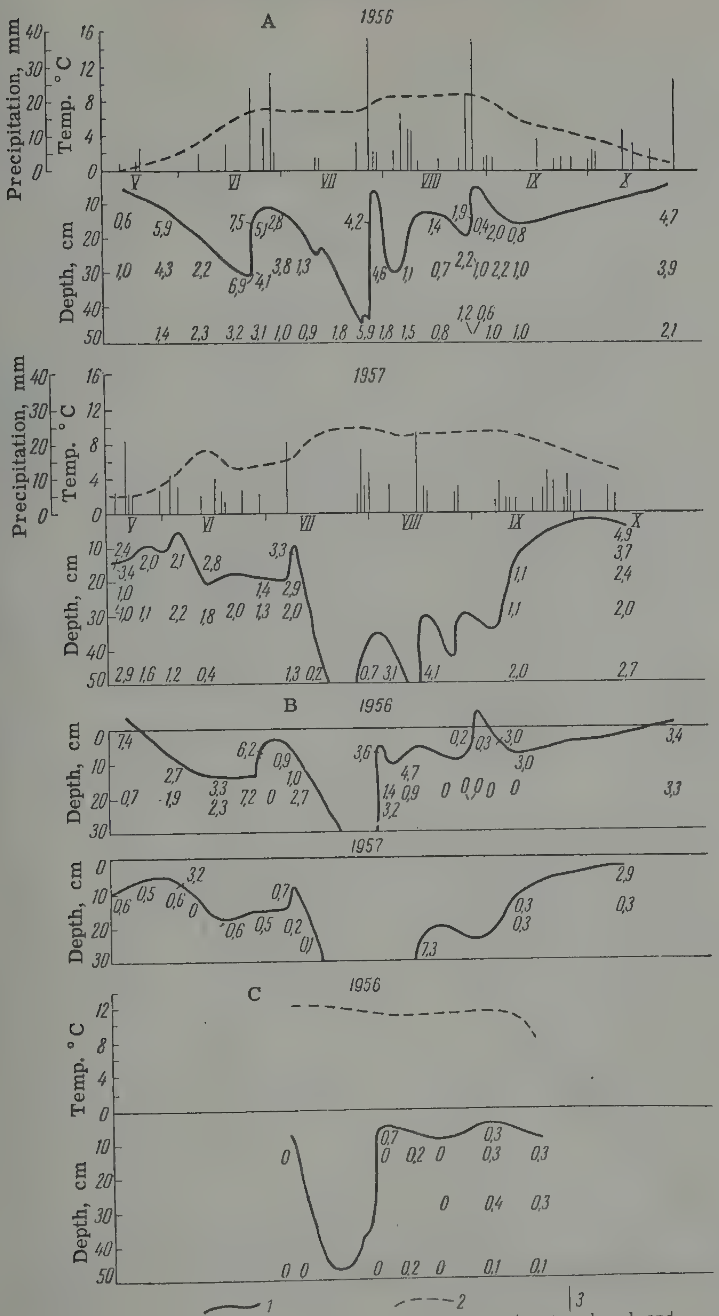


Fig. 1. - Precipitation, soil temperature, ground-water level and oxygen content:

Peat-humus gley soils: A - mature fir stand in a flat area; B - mature fir stand in a slightly elevated area; C - recent cut-over area. 1 - ground water level; 2 - soil temperature at a depth of 30 cm; 3 - precipitation. The figures show the oxygen content (mg/l) at various depths.

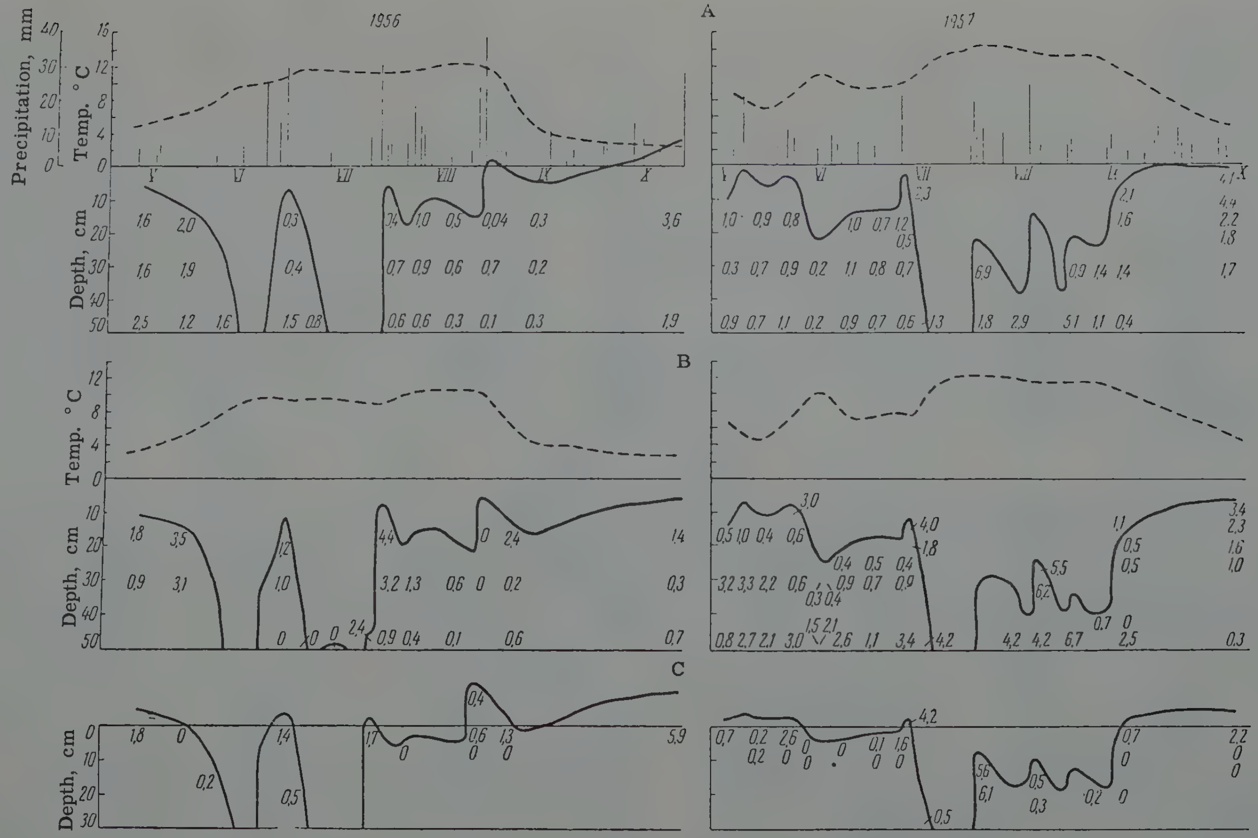


Fig. 2. - Precipitation, soil temperature, ground-water level and oxygen content:

Peat-humus gley soils: A - ten-year-old birch stand; B - twenty-year old birch stand in a flat area; C - twenty-year old birch stand in a slightly elevated area. See Fig. 1 for key to figures.

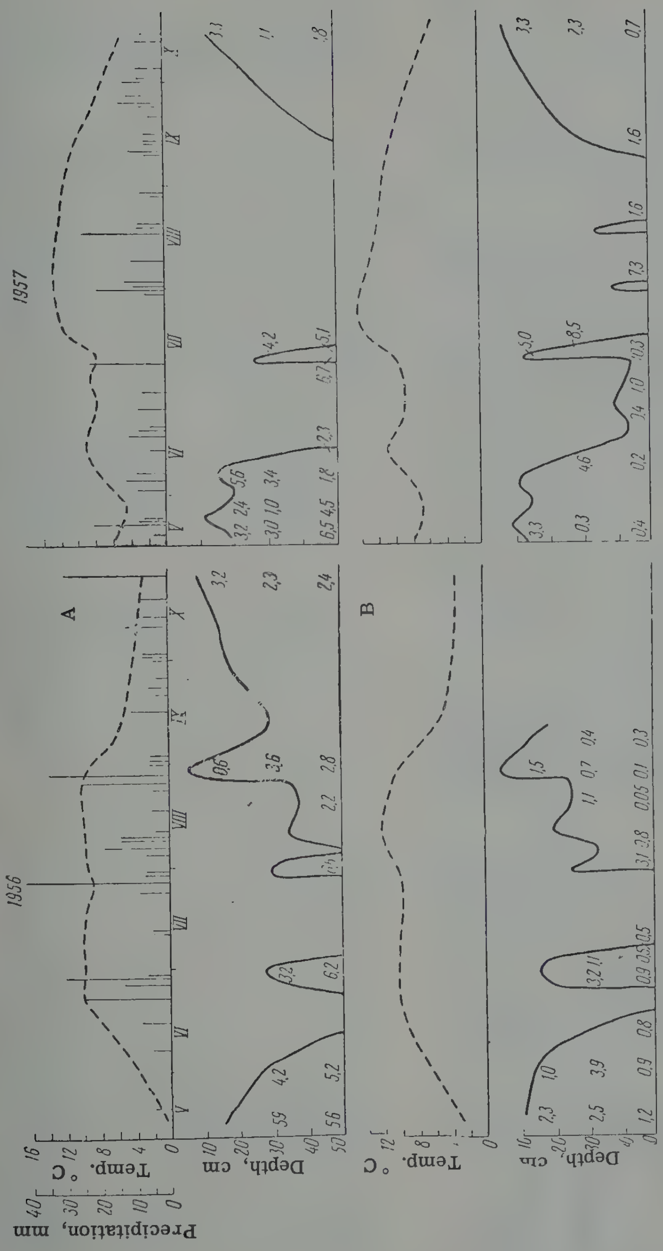


Fig. 3. - Precipitation, soil temperature, ground-water level and oxygen content:

Podzolic soils: A - mature fir stand; B - twenty-year old birch stand. See Fig. 1 for key to figures.

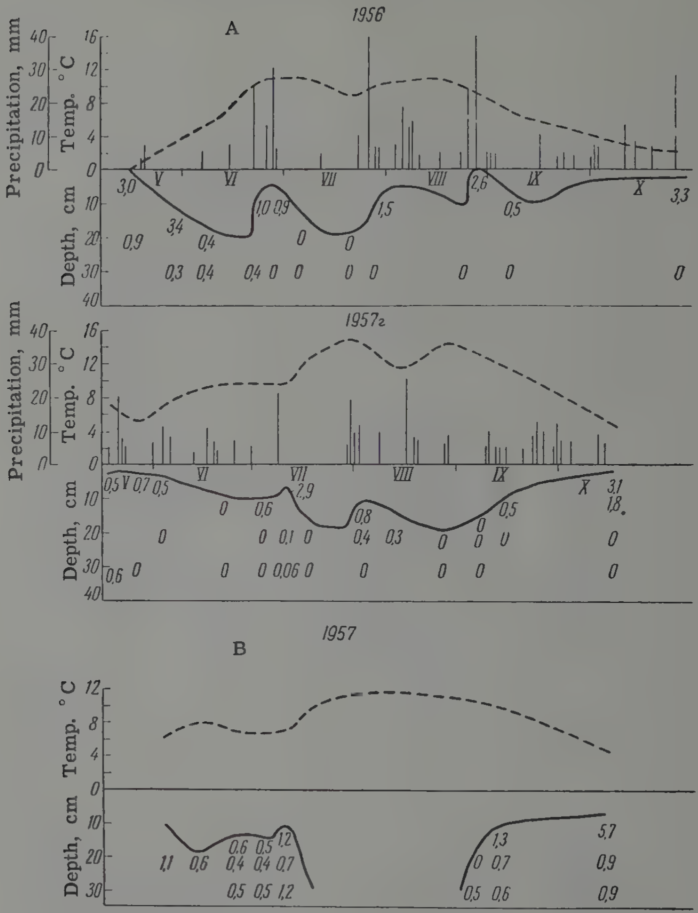


Fig. 4. - Precipitation, soil temperature, ground-water level and oxygen content:

A - mature fir stand on peaty soil; B - mature fir stand on peaty-gley soil. See Fig. 1 for key to figures.

the oxygen content was more than 7 mg/l (the degree of saturation was higher than 50%).

On June 1, the water at depths of 15 and 30 cm contained much oxygen (about 6 and 4 mg/l), evidently as a result of the penetration of melt-water into this stratum, where there was no great consumption of oxygen at the low soil temperature (2° C at 30 cm) during this time. In the first ten days of June, along with a lowering of the soil water level and a fairly slow increase in the soil temperature (up to 4° C at 30 cm by June 11), a decrease in the oxygen content at a depth of 30 cm and some increase at 50 cm was noted; this may have been the result of the movement of oxygen-rich water downward through the soil stratum.

A determination of the oxygen content several hours after a cloudburst on June 22, which raised the soil-water level from 30 to 15 cm, revealed a high concentration of oxygen in the ground waters: 7. 5 mg/l at 15 cm, 6. 8 mg/l at 30 cm and 3. 2 mg/l at 50 cm. The much lower oxygen content in the water samples taken the following day (5. 1 mg/l at a depth of 15 cm and 4. 1 mg/l at 30 cm) testifies to the rapid consumption of oxygen in these humus-rich horizons under the conditions when the temperature has reached 8-10° C.

Up to July 1, there was a further decrease in the oxygen content, in spite of the plentiful rain. During the first twenty days of July there was little rainfall, the ground-water level fell gradually, and the oxygen content was very low (about 1-1.5 mg/l). Cloudbursts at the end of July again saturated the soil with water having a high oxygen content (4-5 mg/l at depths of 15 and 30 cm), so that the soil-ground-water level rose from 45 cm almost to the surface.

During a rainy August and the beginning of September,[2] when the ground-water level fluctuated between 5 and 20 cm from the surface, and the soil temperature at a depth of 30 cm reached 9° C, the oxygen concentration at all depths was very low -- about 1-1.5 mg/l, ranging from 0.4 to 2.2 mg/l. These data are in full accord with the conclusions of Malyanov (5), who showed that a high oxygen content in the ground waters after plentiful rains is observed only when the water level up to that time has been relatively low.

When the low oxygen-content waters have stood at a high level, even very plentiful rains cannot produce any important change in the concentration of oxygen in the ground waters, since the amount of oxygen-rich rainwater diluting the ground water is much less than that of the latter.

In the second half of October[3] the ground water, whose level was at the very surface, contained a large quantity of oxygen (about 4.5 mg/l at a depth of 15 cm and 2 mg/l at 50 cm). The low soil temperature decreased the activity of the microorganisms, so that the oxygen in the plentiful autumn rains was consumed slowly during this period.

The increase in the solubility of oxygen in water at low temperatures is also significant.

From the middle of May to the beginning of June, 1957, the oxygen content in the ground waters was relatively constant: 2-3 mg/l at a depth of 15 cm, 1-2 mg/l at 30 cm and 0.5-1.4 mg/l at 50 cm. The oxygen consumption during this time was probably decreased because of the very slight warming of the soil during the cold month of June, and was compensated by an influx of atmospheric waters from the frequent rains which maintained the high ground-water level.

July and August were much drier in 1957 than in 1956. The ground-water level fluctuated between 30 and 50 cm below the soil surface, at times descending below 50 cm. Individual determinations of the oxygen content in this period showed that the oxygen-rich rainwater penetrated to a depth of 50 cm. The concentration of oxygen at this level reached 3-4 mg/l.

On other dates, when the oxygen supply was not replenished by rainwater, the concentration decreased to 0.2-0.7 mg/l.

A very low oxygen content in the ground waters, when their level was very low and when there was no rain, was also observed in the other plots. For example, in June 1956, in the twenty-year birch stand there was no oxygen in the ground waters at a depth of 50 cm, near the upper level of these waters. Thus one can hardly agree with Bystrov's view (1) that the waters in the deeper layers of the soil may be enriched in oxygen by atmospheric oxygen penetrating through the soil pores.

After autumn, another increase was noted in the oxygen concentration in the waters under mature fir stand (sample plot No. 5).

The basic regular features of the change in the oxygen content in the ground waters that were seen in the case of fir stand may also be observed in that of birch stand (sample plots Nos. 1 and 2), which grow under very similar soil conditions. On the whole, however, the oxygen content of the waters in the soil stratum under the birch stands is much lower than in the case of the fir stand. In the ten-year birch stand for example, during the period of a high soil water level in the second half of the vegetation period of 1956 and the spring and beginning of summer of 1957, the oxygen concentration with rare exceptions did exceed 1 mg/l, and at times was almost zero (Fig. 2A). The twenty-year birch stand presents a similar picture[4] (Fig. 2B). In the fir stand during these periods the oxygen content was usually 1-2 mg/l. This is due to the more rapid consumption of oxygen in the soils below the birch trees, as a result of the greater warming of the soil, and the fact that birch litter decomposes faster than fir litter. Investigations made by microbiologists in the same sample areas have revealed a higher rate of microorganism activity in the birch stand.

A still lower oxygen content (0-0.4 mg/l) was found in 1956 in the ground waters of recent cut-over areas (sample plot No. 8) on similar soil, where a great rise in the ground-water level was observed in the rainy periods and where the soil was most efficiently heated (Fig. 1C).

---

[2] On the whole, the vegetation period of 1956 was characterized by a considerable increase in the amount of precipitation, as compared to the data for many other years.

[3] Observations were not made during the second half of September and the first half of October.

[4] An exception is the data from determinations made from water samples taken at a depth of 50 cm in 1957. Probably because of some local peculiarities, a freer flow of water from the surface entered the filter from which these samples were taken. Parallel determinations in sample area No. 2 at this depth were not made.

Determination of the oxygen content in the water samples taken from the surface layers of the soil in micro-depressions has shown that the waters of these depressions as a rule contain much less oxygen that those in average positions throughout the micro-relief of these areas. In the mature fir stand (sample area No. 5), for example, during the period of high ground-water level in 1956, there was no oxygen at 20 cm below the soil surface in a small depression, about 2 m^2 in area (Fig. 1B); in the adjacent flat areas, at depths of 20 and 30 cm, the oxygen content was about 1-2 mg/l. A similar picture was also presented by the birch stand (Fig. 2C). Often, in samples of water taken from the soil of micro-depressions, no great increase in the oxygen was observed after cloudbursts. The rain water accumulates in the depressions, but there is almost no penetration of the soil stratum, which has been saturated up to this time by oxygen-poor water. Sometimes, when the general ground-water level is lower, a higher oxygen content is observed in the waters from depressions; this is probably due to the accumulation in the depressions of rainwater, which in this case does penetrate the upper layers of the soil.

These data show that a determination of the oxygen content of the waters in natural depressions, as well as in special wells and holes, as has been made by some investigators like Hesselman (8) and Veretennikov (2), cannot accurately reflect the content of oxygen in the soil and ground waters of the given area.

In podzolic soils, where the rainwater more often penetrates to the deeper soil layers and where the oxygen consumption is lower because of the smaller amounts of organic matter, the oxygen content (Fig. 3) as a whole is higher than in the peat-humus gley soils. Here too, however, on particular dates a low oxygen concentration has been observed in the water samples. This is true mainly of birch stand (sample plot No. 7). The decrease in the oxygen content in the birch-stand waters may only partly be explained by the difference in the rates of oxygen consumption already noted between birch and fir forests. Some significance may doubtless also be attributed to inequalities between the two plots being compared: the greater slope of the surface and the deeper occurrence of the impermeable clay loam in the fir-stand area result in greater fluctuations in the ground-water level, which on the average is much higher in the birch-stand. The low oxygen content at the depth of 50 cm during most of the period of observation is probably to be explained by the retention of water on the surface of the impermeable layer.

In the sedge-sphagnum fir-stand on peaty soil (sample plot No. 9), the level of the soil waters in 1956 and 1957 fluctuated within the surface layer from 0-20 cm. There was oxygen usually only in the soil waters in the uppermost layer, and even here the concentration was less than 1 mg/l. Only very rarely, after cloudbursts, did the oxygen content in the uppermost layer exceed 2 mg/l. During periods when the soil water level was low there was no oxygen even at the surface (Fig. 4A).

The effect of the oxygen-rich precipitation (which dilutes the oxygen-poor soil-ground waters) scarcely extends to the deeper layers: only in rare cases, after a rain, does the oxygen concentration reach several tenths of a milligram at the depths of 20 and 30 cm below the surface of the soil. A post-autumnal increase in the oxygen concentration, in contrast to peat-humus gley and podzolic soils, is observed only in the uppermost 10-cm layer. A somewhat higher concentration than usual was seen in the autumn of 1956, when there was a low soil temperature (<6° C) at depths of 20 and 30 cm; this, however, was no more than 0. 5 mg/l.

Very unexpected results were obtained in the native fir-stand. The oxygen content in the ground waters in this forest type, which belongs to the group of forest types with so-called circulating oxygen-rich waters, turned out to be very low and to show little change with depth and on the various dates of observation in 1957 (Fig. 4B). In most cases the waters contained from 0. 5 to 1 mg/l of oxygen. The highest content was 1. 3 mg/l (with the exception of post-autumnal dates).

The investigations show that the behavior of the oxygen content of the ground waters in the forest soils of this territory is affected by three basic factors: 1) the soil temperature, which determines the consumption rate of oxygen in various biological and biochemical processes that take place within the soil; 2) the penetration of oxygen-rich precipitation into the surface of the soil; 3) the outflow rate of oxygen-poor waters from the soil stratum. The organic matter content in the given horizon, the properties of this matter (especially its resistance to decomposition) and the activity of microbes and other factors that affect the rate of oxygen consumption are also important.

Under soil temperatures that are usual for the greater part of the vegetative period (8-12° C), there is a rapid oxygen consumption in the soil stratum that contains a great deal of organic matter (except for podzolic soils). The decrease in the oxygen concentration in this period may be clearly traced even within twenty-four hours. After the end of the vegetative period the lowering of the soil temperature to 4-0° C suppresses the biological processes in the soil; this is accompanied by a diminished oxygen consumption and an increased oxygen content in the soil-ground waters (up to 3-5 mg/l in the upper layers). The increased oxygen intake from the cold autumn rains, which is due to the greater solubility of oxygen in water at low temperatures, is also a factor of some significance.

As spring approaches, the oxygen content in the waters of the soil stratum usually decreases to 1-2 mg/l. Meltwater containing a large amount of dissolved oxygen is not in all cases capable of enriching the soil waters with oxygen, since the soil thaws slowly, especially in coniferous forests; and the outflow of soil waters, which have been filling the soil stratum almost to the surface since autumn, is prevented during this period. The meltwater runs off the surface and only part of it penetrates the soil. The increased oxygen content at low soil temperatures in the early spring is therefore not as distinct as in late autumn.

The rainwaters bring a considerable quantity of oxygen dissolved in them to the surface of the soil. But when the level of the oxygen-poor ground waters is high, even a large amount of precipitation cannot essentially change the oxygen concentration in the ground water. Saturation of the soil with water having a high oxygen content is observed after rainfall only when the ground-water level up to that time has been relatively low.

Thus the enrichment of water in the soil with dissolved oxygen derived from the oxygen in the air which has penetrated through pores in the soil is evidently not of essential importance, since the diffusion rate of the oxygen in water is very low, and the free waters in the soil are isolated from direct contact with the air by a capillary fringe.

The oxygen content in the soil waters is thus generally the higher, the greater the fluctuations in the level of the ground waters and the greater, in consequence, the possibility of the penetration of the precipitation into the soil. Wherever the outflow of water from the soil stratum is hindered because of the nearness of an impermeable layer or because of the slight inclination of the ground, the ground-water level is lowered very little during the period of low precipitation, and low-oxygen moisture "does not have time" to make room for the new influx of atmospheric waters. Under these conditions even the surface layers of the soil are constantly deprived or almost completely deprived of oxygen (as, for instance, in sample area No. 9 in the sedge-sphagnum fir-stand). Acceleration of the outflow of water (in peat-humus soils as compared to peaty soils and in podzolic as compared to peaty-humus soils) is accompanied by increased oxygen in the waters of the soil stratum.[5] Whenever, despite the rapid outflow of the ground waters, their level remains high during most of the period of vegetation, the waters in the soil contain, as shown by the data on the determinations made in the native fir-stand area, very little dissolved oxygen. One would, of course, hardly expect to find a high oxygen concentration in waters that flow along the surface of an impermeable clay loam through soil which is very rich in organic matter; and such soils occupy a great part of the region, including watersheds.

Experimental data, such as those of Hesselman (8) and Malyanov (5), indicate a very rapid loss of dissolved oxygen in water that is in contact with a substratum rich in organic matter. Moreover the view occurs frequently in the literature of forestry and geobotany that the improved growth of several forest types with circulating moisture is to a considerable degree due to "improvement in the supply of oxygen to the roots as a result of the fact that the water is not completely stagnant" -- Sukachev (7, p. 158). P'yavchenko (6) considers that a more or less sufficient supply of oxygen in the upper horizon of the bog soil in circulating surface streams is produced by constant movement of the ground waters. This view is not supported by the facts. It is apparently more correct to consider that the better growth of forest vegetation in several forest types with circulating moisture is due mainly to the influx of nutrient elements, carried by the waters in the root stratum of the soil that is flooded during much of the period of vegetation. The periodic lowering of the ground-water level, especially in such forest types as the native firs, is doubtless also important. During these periods the biological activity of roots and microorganisms is carried on through the expenditure of oxygen that has entered the soil from the air. Thus the greater oxygen content in the ground waters must be attributed not to enrichment of the waters with oxygen by the movement of these waters through the soil, but rather to the more or less rapid removal from the given area of water whose oxygen supply is spent; this makes it possible for the oxygen-rich water from the atmosphere to penetrate the soil.

Received April 17, 1958

BIBLIOGRAPHY

1. BYSTROV, S. V. 1936. Contributions to the knowledge of the podzol forming

---

[5] There is also an improvement in the conditions of aeration in the same direction, when the period is increased during which the appropriate layer of the soil lies above the level of the ground waters.

process. Some data on the oxygen content of the water in podzolic and gley soils. Trudy Poch. In-ta im. V. V. Dokuchayeva Akad. Nauk SSSR Vol. 13.

2. VERETENNIKOV, A. V. 1957. The structure and function of the root system of pine trees in relation to temporary excess moisture in the soil. Trudy Leningr. lesotekhn. Akad. No. 82.

3. VERNER, A. R. and YE. A. GORDEYEVA. 1952. The content of oxygen and hydrogen and hydrogen sulfide in the ground waters (upper water level) of Baraba. Pochvovedeniye No. 11.

4. LATYSHEVA, M. N. 1936. Changes in the oxygen content of ground waters. Problemy sov. Pochvoved. No. 3.

5. MALYANOV, A. P. 1937. Dissolved oxygen in soil water. Trudy Konfer, po Pochvoved. i Fisiol. kul't rast., I, Saratov.

6. P'YAVCHENKO, N. I. 1957. Bog forest types in the Northern Dvina basin. Trudy In-ta Lesa Akad. Nauk SSSR Vol. 34.

7. SUKACHEV, V. N. 1938. Dendrology and the foundations of the geobotany of forests. Goslestakhizdat.

8. HESSELMAN, H. 1910. Om vattnets syrchalt och dess inverkan på skogsmarkens försumping och skogans växteighet (In Swedish). Medd. Statens skogsforsoksanstelt, No. 7.

DISCUSSION

AN ATTEMPT AT A SYSTEMATIC CLASSIFICATION OF THE SOILS IN THE STEPPE ZONE OF THE USSR[1]

YE. N. IVANOVA and N. N. ROZOV
V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

The first plenary session of the Joint Committee on the Nomenclature, Systematization and Classification of Soils, on the basis of suggestions made earlier,[2] clarified the definitions of the main taxonomic units in the classification of the soils of the USSR. In preparing the present materials the authors have proceeded on the basis of the definitions of group, subgroup, genus and species published in the Pochvovedeniye, 1957, No. 8.

The steppes of the USSR occupy extensive territories; they are characterized by their enormous east-west extent and by the great variety of natural conditions prevailing in them. In the west they are bordered directly by the steppe areas of Hungary, Rumania and Bulgaria and in the east by the extensive steppes of Mongolia and Northeastern China. All these territories make up the single subboreal steppe region of Eurasia. This region has been very intensively utilized, since it is the world's greatest agricultural area; its soils have been studied in great detail. Medium- and large-scale aerial photographs have been made of large areas, and a great variety of soils has been found.

The variety of soil is due to: 1) the manifold changes in the bioclimatic conditions over the extensive area from the Danube basin in the west to the Sungar' basin in the east, 2) the great variety in lithology and geomorphology, encompassing areas that have been repeatedly covered by continental glaciation and areas that have never undergone the effects of glaciation, 3) the diversity and, in places, long-lasting effects of agriculture.

Steppe soils, if one studies their complete genetic profiles (down to the depth of full saturation under the conditions of a perched water regime), are distinguished by a great variety of structures and by the distinctness of both their organogenic and their mineral-salt horizons.

The Soviet genetic classification of soils takes into account the soil properties in close association with their origins and studies the basic development of the soil profile both in regard to the transition from the soil-forming parent material to the soil and the transition from one soil group to another, as related to changes in the climatic conditions and in the topography.

A peculiar feature of Soviet papers on soil genesis and classification is the fact that for a long time special attention has been given to zonal changes in the soils and the zonal succession of soil development, while at the same time the facies or provincial changes in the soils (from west to east), which are very important in the case of the steppe region, have been insufficiently studied and are not properly reflected in soil classification and nomenclature.

---

[1] This communication was prepared by the authors, aided in particular sections by F. Ya. Gavrilyuk, O. V. Makeyev, N. A. Nogina and K. A. Ufimtseva, and discussed at the Second Plenary Session of the Joint Committee on the Nomenclature, Systematization and Classification of Soils in the Academy of Sciences of the USSR.

The published text incorporates some of the remarks and suggestions made at the Plenary Session (see Pochvovedeniye, 1958, No. 9).

[2] Prasolov, L. I. General principles of soil classification and nomenclature. A report to the All-Union Congress on the Classification of Soils, December 15 to 18, 1935. Pochvovedeniye 1939, No. 7, p. 10.

Gerasimov, I. P. 1954. The scientific basis of the systematization and classification of soils. Pochvovedeniye No. 8.

Ivanova, Ye. N. 1956. A classification of the soils in the northern part of the European territory of the USSR. Pochvovedeniye No. 1.

Gorshenin, K. P. 1955. The fundamental principles of soil classification. Pochvovedeniye No. 2.

The resolutions of the First Plenary Session of the Joint Committee on the Nomenclature, Systematization and Classification of Soils took the following important step: it was resolved that "both subzonal and provincial changes in natural conditions" must be taken into account in distinguishing soil subgroups.

The second important decision of the Plenary Session in the realm of soil classification was the establishment of the concept of a "soil genus."

The third essential question touched on in the resolutions of the Plenary Session was that of the definition of the concept of a "soil species." According to the definition adopted, soil species are distinguished within genera by the degree of development of the soil forming processes. Inasmuch as the many processes which contribute to the formation of the soil profile are associated with each other, however, the soil species will naturally be characterized not by one criterion but by a complex of criteria, among which one or more will be recognized as the main ones and reflected in the name of the species.

The foundations of the systematic classification of steppe soils were laid by V. V. Dokuchayev; essential further contributions to this problem were made by N. M. Sibirtsev, P. A. Kostychev, L. I. Prasolov, S. A. Zakharov, N. A. Dimo, I. P. Gerasimov, K. P. Gorshenin and many other Soviet soil scientists.

The present projected systematization of steppe soils takes account of many materials, both published and unpublished, including data on the chernozems and chestnut soils of the adjoining regions obtained by foreign and in part by Soviet scientists. The present authors consider it essential to include these territories in the scope of the discussion, despite the limited available materials, since only under these conditions may one achieve any thoroughness in the distinction of the main systematic groups of steppe soils and make the necessary connection with the papers on soil classification by scientists of the adjoining countries.

The steppe zone is made up of the following genetic soil groups: chernozem, meadow-chernozem, chestnut, meadow-chestnut, meadow and meadow-bog, solonchak, steppe solonetz, meadow solonetz and solodi.

The independent groups of steppe soils that have been distinguished are recognized by the majority of soil scientists at the present time. Some soil scientists, moreover, point out that the chernozem soil group encompasses soils with too great a variety of properties and structures, and suggest differentiating two independent types of chernozems: "forest-steppe chernozems" (podzolized, leached and typical) and "steppe chernozems" (ordinary and southern).

Since the time of S. S. Neustruyev's work the genetic uniformity of the chestnut soil group has also been doubted. Suggestions have been made for combining the light chestnut soil subgroup with that of the brown desert-steppe soils, on the basis of the fact that in their properties (saline and solonetz-like) the light chestnut soils of the Caspian area and Kazakhstan are closer to the brown desert than to the dark chestnut soils. In recent years, however, investigations in the East (the Tuvinian Autonomous Region, Buryat-Mongolia, the Mongolian Peoples' Republic, and China) have shown that salinity and solonetz-like are not diagnostic criteria for all the soils of the chestnut group. The soils of the eastern facies lack these criteria, and within the chestnut soil group a very gradual transition has been observed from dark to light chestnut in relation to the humus and carbonate profiles. As far as their agricultural characteristics are concerned, the light chestnut soils of the eastern facies are also close to the other subgroups within this group, inasmuch as they are cultivated by the methods used in dry-land agriculture (where there is not always enough precipitation), whereas the brown desert soils are cultivated only in irrigated lands.

CHERNOZEMS

Chernozems are soils developed under many years' growth of grassy steppe vegetation in forest-steppe and steppe zones under the conditions of incomplete saturation with water, or else complete saturation in the north of the chernozem zone in individual, very wet years. The chernozems are, above all, characterized by an accumulation of humus and exchangeable cations in the humus horizon; the greater part of them has a well-defined granular structure, lack of dissociation of the secondary minerals and a uniform distribution of the mass of silicates and of the clay fraction throughout the profile. They are also typified by an accumulation of biogenic carbonates in the soil profile and their migration in the stratum containing the roots, so that the transformation of the organic and mineral substances takes place under the conditions of a neutral or weakly alkaline reaction in the soil solution. A salt profile is also characteristic of chernozems. They all contain carbonates, the distribution of which in the soil profile varies in the different

AGRONOMY SEMINA
305 DAVENPORT HA

hernozem subzones and facies. The carbontes in the chernozems of the northern subzones re somewhat alkaline, since they occur well elow the surface, whereas in the chernozems f the southern subzones the carbonates pproach the surface, and at a certain depth here is an appearance of easily soluble salts wing to the smaller thickness of the moistened oil layer.

There are essential differences between the umus and salt profiles of the various chernozem subzones and facies; this is the basis for istinguishing subgroups in each facies in ccordance with the new definition of this taxoomic unit in soil classification.

At the present time, within the chernozem zone three facies and three corresponding groups of facies subgroups may be distinguished: a Western (Southern European or Black Sea area), a Central (continental) and an Eastern (East Asian) facies.

The subgroups in the Western and Eastern facies groups form the transitions between the chernozem soil group and the respective brown forest and cinnamon-brown soil subgroups of the Western European and East Asian regions. Since the facies and provinces of the soil mantle are ultimately determined by the outlines of the continents and the distribution of water and dry land over the earth's surface, we have been compelled to use geographic terms in designating these subdivisions, instead of the names of soil zones and subzones. Each of these facies has its own peculiar features of soil formation, as determined by the local bioclimatic conditions.

Central (continental) facies

The Central (continental) facies is characterized by: long winters, warm summers with a low maximum of precipitation in summer, and a fairly dry and warm spring. This is the reason for the relatively shallow saturation of the soil in spring and the limited reverse upward migration of the solutions, which are interrupted by the fairly rapid drying of the soil surface in spring and intercepted at depth by moisture from the vegetation.

In the most continental provinces of this facies the soil is frozen to great depths in winter, thawing is delayed and in summer the soil is frozen not far below the surface for a long time; this may give the soil a certain meadow-like character.

Western (southern European or Black Sea area) facies

The Western (southern European or Black Sea Area) facies is characterized by warm moist winters, very hot summers and dry springs. During the winter the soil is wetted with water to great depths, but with the onset of warm spring days and the beginning of vegetative growth moisture then flows toward the surface and carbonates are precipitated in the top layers of the soil. This process differs in the various subzones of these chernozems. In the deep-mycelium-carbonate and mycelium-carbonate subzones the soil is wetted to great depths; in the upward moisture movement in spring most of the moisture containing the soluble substances does not reach the surface and is used up in transpiration, so that the soluble substances are precipitated in the form of carbonate veins (and of encrustations within a very limited layer) in the soil profile, thus causing the soil to effervesce in HCl.

In the subzone chernozem of well defined mycelium-carbonate of shallow thickness which has warmer and drier spring season, there is an intensive heating of the soil, so that the moisture flow upward in early spring reaches the surface, evaporates and fills the uppermost soil layers with precipitated carbonates which cannot be seen under the lens but which cause the soil to effervesce. Depending on the amount of vegetation, the solutions are intercepted by the roots at some depth from the surface and form carbonate encrustations, webs and molds (usually between the depths of 30-50 cm).

In the thick and medium-thickness of well-defined mycelium-carbonate chernozems there is generally less moisture penetration of the soil (because of the smaller amount of precipitation) and a less extensive carbonate migration to the surface.

Eastern (East Asian) facies

The Eastern (East Asian) facies of the chernozem zone is characterized particularly by the climatic contrast between the very dry snowless winters and dry springs and the wet summers with their downpours of rain.

The soils of the Eastern facies group are also typified by freezing to great depths in winter, retention of the seasonal frosts for a long time in the lower soil horizons, drying of the soil in spring and then the beginning of the spring vegetative growth coinciding with the onset of the rainy season.

The great fluctuation throughout the year in the amount of precipitation and its concentration in the summer is the reason for the periodic wetting of these soils. For this reason also there is a discrepancy in the soil profile between the removal of the easily mobile salts and gypsum on the one hand and of the carbonates on the other. In wet years the former are carried away by the summer rains down to a very great depth, whereas the latter, though they show a great tendency to be removed, are relatively stable in the soil profile. The depth at which the soil will effervesce is not at all constant and thus cannot be used as a criterion for the division of the chernozems of this facies into subgroups.

In respect to the humus contents and the thickness of the humus profile, the chernozems of the Eastern facies are usually relegated to the category of low-humus, low-thickness soils, because of the late beginning of vegetation, the shallow root systems and the relatively low natural biological yield as compared to chernozems of the other facies.

A brief review of the diagnostic features of the various chernozem subgroups follows.

Chernozem Subgroups of the Central Facies Group. The nomenclature of the chernozems in this facies has been built up during the course of a long period of history and has become established in numerous large-scale soil maps. This nomenclature is not distinguished for the strictness of its selection of terms and along with genetic terms uses geographic terms (such as "southern chernozem"), as has repeatedly been pointed out in the literature. Although we agree with these remarks, we nevertheless believe that the concept "southern chernozem" has acquired so many purely genetic associations during its long use that it has by now become a scientific term without any geographic implications.

The term "typical chernozem" will be used only for the central subgroup in the continental chernozem facies, in accordance with the decision of the All-Union Congress of Soil Scientists in 1950 and in view of the fact that during all these years not a single concrete suggestion has been made for its replacement. The words "thick" and "rich" that are often used in soil mapping to designate this subgroup are not applicable, since they indicate the soil species and are widely used as species designations.

The podzolized chernozems are characterized by a medium amount of humus in the humus horizon (30-40 kg per 1 m^2) and by the depth at which the carbonate horizon occurs: between the humus and the carbonate horizons there is a non-carbonate layer. The carbonates in these soils occur at such a great depth that they cannot always be drawn up to the humus horizon; therefore in the lower part of the latter there may be a periodic deficit of calcium in the soil solution and a weakly acidic reaction produced by the effect of the biologic medium, and there is a lesser degree of cation saturation -- that is, the conditions here favor some degree of podzolization (in the form of differentiation of the clay through the soil profile). The weakly acid conditions cause a certain solubility of the humus, which correspondingly facilitates clay migration. In the upper part of the humus horizon the sod forming process results in an intensive accumulation of ash elements from the plant litter, the effect of which is to neutralize the acidity and to cause the formation of new organic-mineral colloids with a high adsorptive capacity. The lower part of the humus horizon is characterized by a periodic weakly acidic reaction (under the action of the root systems), since here there is a limited intake of bases both from above and from below. Here, too, there is a concentration of the signs of podzolization, which are reflected morphologically in the form of a "siliceous powder" at the boundary between the humus and the transitional horizons. A nut-like structure is also observed in the transitional horizon (BC). In certain cases the chernozems contain evidence of considerable surface podzolization (removal of the sesquioxides and the clay fraction). These indications must be taken as relicts of the preceding phase of soil formation and the soils must be considered as aggraded.

Leached chernozems have a greater amount of humus in the humus layer (35-55 kg per 1 m^2). The carbonate horizon lies at such a depth that the calcium in it can reach the humus horizon in its seasonal migrations. Leached chernozems therefore have a neutral reaction, and lack a "siliceous powder" at the lower border of the humus layer. In the A horizon of leached chernozems there is a greater fixation of the organic matter and a greater content of exchangeable cations. In the BC horizon the "clay formation" is weak (or lacking) and the structure is cloddy (granular in the humus horizon). Sometimes the A horizon is low in sesquioxides and in the clay formation (relict vestiges).

Typical, ordinary and southern chernozems are characterized by effervescence in the humus horizon (A or B_1). In these soils the carbonates in migrating produce a neutral or weakly alkaline reaction throughout the whole soil profile. The migration of carbonates is limited, however, and does not lead to the formation of new compounds in the upper part of the humus horizon. These soils are neither podzolized nor leached.

The typical chernozems are characterized by the greatest intensity of the chernozem forming process and the largest amounts of humus (65-75 kg per 1 m^2). These include the "rich" and "thick" chernozems of the old nomenclature -- that is, the provincial groups of typical chernozems are as follows: 1) rich low-thickness, 2) rich medium-thickness, 3) medium-humus thick and 4) low-humus high-thickness.

Ordinary chernozems have properties very close to those of the typical chernozems; they are distinguished by lesser amounts of humus (35-45 kg per 1 m²) and a decreased adsorption capacity, as a result of the somewhat smaller yield of vegetation in the grass steppe zone as compared to the meadow steppes (with their typical chernozems) and the more rapid decomposition of the mass of vegetation and formation of simple mineral salts. The ordinary chernozems of the European part of the USSR often contain a horizon, at a depth of more than 3-4 m, in which there is a precipitation of easily soluble salts and gypsum (salt); the salt horizon in the ordinary chernozems of Western Siberia appears at a depth of about 200 cm.

Southern chernozems are formed beneath the grasses of the drier steppes. The vegetative yield here is still smaller and the mineralization of the plant litter still more rapid. These soils therefore contain lower humus content (20-25 per 1 m²). Because of the intensified mineralization of the plant residues, concentration in the soil solution is increased and a tendency toward the creation of solonetz-like conditions is superimposed on the illuvial carbonate horizon. The humus horizon in these soils has a still lower adsorption capacity, contains less humus and has a shallower thickness. There is effervescence at the surface or in the upper part of the humus horizon in the fine clay soils of the more continental provinces. These may evidently be considered as a kind of peculiar "residual carbonate" chernozem on carbonate fine clay loam, from which the leaching of the carbonates is greatly retarded under the arid conditions. The gypsum (and salt) horizon appears at a depth of 150-250 cm or more in the southern chernozems. Directly above this is a quite clearly distinguishable solonetz-like horizon.

All the enumerated chernozem subgroups may be divided into genera according to the genetic criteria in the soil profile; these criteria are determined by the properties of the soil-forming parent materials (salt and carbonate content, etc.) or are connected with the preceding phase of soil formation (podzolization, solonetz formation, solodization).

The following genera may be distinguished among the various chernozem subgroups of the central facies:

1) genera corresponding to the subgroups (proper podzolized, leached, typical, ordinary and southern chernozems);

2) residual podzolic genera of chernozems may be distinguished among the podzolized and leached chernozem subgroups; they are characterized by remaining vestiges of podzolic soil formation (upper soil horizons with low contents of clay and sesquioxides).

This characteristic is not constant in soils and in the course of time disappears with the accumulation of secondary minerals caused by the sod forming process.

3) "coarse" chernozem genera, which are low in humus, effervesce very weakly and have a coarse texture (coarse clay loam and sandy loam); these genera are characteristic of leached, ordinary and southern chernozems;

4) residual-carbonate chernozems are formed on compact carbonate parent material and effervesce from the surface of the clay in the A horizon; they are found among typical, ordinary and southern chernozems;

5) solonetz-like chernozems are both salinized to great depths and characterized by the presence of easily soluble salts in the upper layers of the parent material and of exchangeable sodium (not less than 5% of exchange capacity) in the lower part of the humus horizon, which has a prismatic structure. Particle size analysis and adsorption capacity may reveal solodization. The soils are developed on saline parent materials. These genera are typical of the ordinary and southern chernozem subgroups.

6) residual solonetzic-solodized chernozems have a morphologic profile very much like that of the solonetz-like chernozems. They are distinguished by the lack of exchangeable sodium and the deeper occurrence of the easily soluble salts. Particle size analyses (and sometimes also the exchange capacity) reveal an eluvial horizon. These are found among the ordinary and southern chernozem subgroups.

7) non-carbonate chernozems are developed on the weathered products of older parent materials (of the Tertiary weathered crust), which are lacking in calcium silicates. These soils have a somewhat less intensive sod forming process (with a smaller thickness of the humus horizon and a lower humus content) and lack a carbonate horizon. The reaction is neutral and weakly alkaline.

Chernozems are separated into species according to the intensity of the sod forming process and the degree of development of their salt profile. After the intensity of the sod forming process, the soils are divided according to the thickness of the humus horizon and the accumulation of humus in them.

According to the amount of humus in the upper ten-centimeter layer of the soil, the chernozems are classed as rich (more than 9% humus), medium-humus (from 6-7 to 9% humus), low-humus (from 4 to 6-7% humus) or

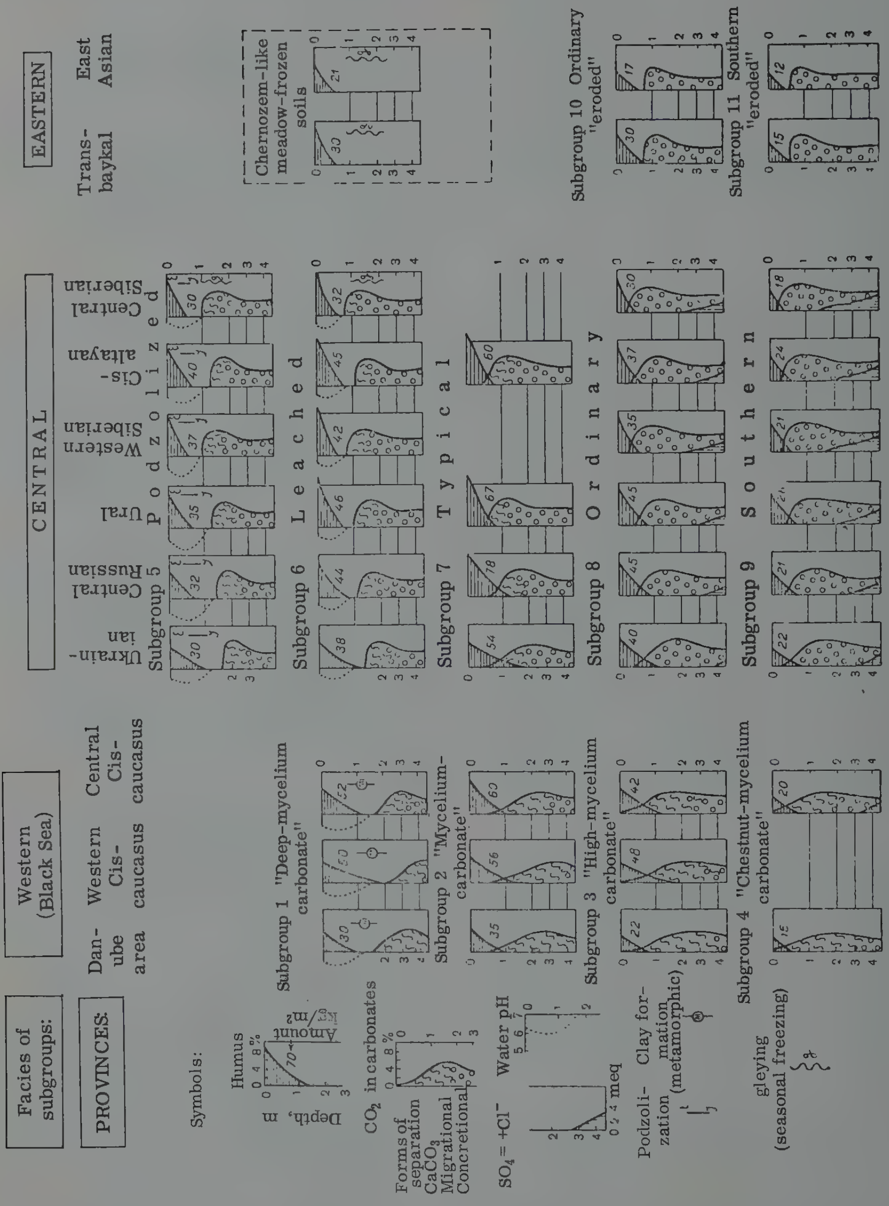


Fig. 1. - The basic features of the chernozem groups and subgroups (diagrams showing principles).

lightly humic (less than 4% humus).

According to the thickness of the humus orizon, A and B_1, in which the humus color redominates,[3] the soils are classed as:) very thick (more than 120 cm), 2) thick 80-120 cm), 3) medium-thick (40-80 cm) or) thin (less than 40 cm), as was decided by he All-Union Congress in 1950.

If necessary, especially in the case of thin hernozems, each of the above thickness categories may be still further subdivided into two hicknesses; basic and shallow. Among the hin chernozems, for example, it may be ecessary to distinguish soils with a humus orizon thinner than the plowed layer; such soils may be called shallow thin ($A + B_1$ less han 25 cm), whereas the soils in which the hickness of $A + B_1$ is about 40 cm are thin soils. According to the degree of distinctness of the salt and mineral profile, the soils may be differentiated by the extent of podzolization, solonetz-formation, solodization, leaching, etc.

This classification of the chernozems by the development of the sod forming process and the salt profile in the main genera characterizes the provincial variations of the soils in the central facies (see Figure 1). Thus, for example, a thin chernozem with concentration of humus and a concentration of the salts relatively close to the surface are typical features of the chernozems of the Western Siberian and Central Siberian provinces; medium thick chernozem with a more uniform distribution of the humus and a relatively deep occurrence of the salts are characteristics of the Cisaltayan and Ural provinces; and a still more extended humus profile, reaching 100-140 cm in the typical chernozem subgroup, with a still deeper position of the salt horizon, distinguish the chernozems of the Central Russian and Ukrainian provinces.

Chernozem Subgroups of the Western (Southern European and Black Sea Area) Facies Group. The southwestern part of the chernozem zone, in the area of the Ciscaucasus, the Crimea, Southern Moldavia, Rumania and Bulgaria, differ both in nature and in their agricultural aspects from the other parts of the zone. These chernozems have been studied by L. I. Prasolov, S. I. Tyuremnov, S. A. Zakharov and S. S. Neustruyev. It has been shown previously that there is good reason for considering the chernozems of this part of the zone to belong to a special group of subgroups, with a different carbonate behavior and a high degree of biologic activity (in regard to both the accumulation and the decomposition of the organic matter).

Up to the present time, beginning with L. I. Prasolov, the chernozems of the southwestern part of the zone have been studied mainly in their regional aspect, so that their nomenclature is frequently made up of geographic terms. This terminology, however, has come to be widely used in investigating soils. Such an approach has made it possible to discover a number of geographical peculiarities of chernozem formation, but has impeded the systematic classification of these soils. Chernozems "of the Azov Sea area" and "Ciscaucasus" chernozems have been considered in different papers sometimes as subgroups and sometimes as species, or else as a unique subdivision within the framework of the main category of chernozems. Some of the chernozems of Rumania and Bulgaria were for a long time taken to be dark-chestnut soils.

The new concept of the soil subgroup, as set forth previously, opens up new possibilities for the systematization of the soils in the southwestern part of the chernozem zone and for differentiating a number of independent chernozem subgroups in this area.

Treatment of the designations of these subgroups involves great difficulties, since the geographic terminology is of course not applicable and terms with genetic meanings are required. Many investigators have long given their attention to the high migration capacity of the carbonates in these chernozems and the associated mycelium form of carbonate separation, especially in the upper part of the profile. This mycelium form taken by the carbonates is the concrete expression of the moisture, thermal and biological conditions in these soils. In designating the chernozem subgroups discussed below, the present authors therefore suggest that the term "mycelium-carbonate" chernozems be considered. Here, since the names of subgroups are involved, this term must be understood broadly as referring not only to the development of a carbonate mycelium within a given time in some specific soil profile, but also to the whole complex of chernozem properties that are reflected physically in the predominance of migration of carbonates (veinlets, little tubes, mycelium) over other forms.

On the basis of the term "mycelium-carbonate chernozems," the following terminology may be suggested:

---

[3] The thickness of the humus horizon ($A + B_1$) in investigations in the field is determined visually, by the predominance of the humus coloration. Analyses have shown that this boundary passes through the layer containing 2-1.5% of humus, so that in the more humic soils and in the carbonate horizons it passes through a higher humus content than in low-humus and non-carbonate soils. The total amount of humus was calculated from the stratum with a humus content greater than 1%; this usually is somewhat thicker than the $A + B_1$ horizon.

Deep-mycelium-carbonate chernozems (Ciscaucasus and Danube basin leached chernozems), which are analogous to the leached chernozems of the continental facies groups.

Mycelium-carbonate chernozems (Azov Sea area, Ciscaucasus and Danube area slightly leached chernozems), which are analogous to the typical chernozems of the continental facies.

Shallow-mycelium-carbonate chernozems (Azov Sea area, Ciscaucasus and Danube area carbonate chernozems; these are the "chocolate-colored chernozems" of the Rumanian soil scientists), which are analogous to ordinary chernozems, with the important difference that the precipitates of easily soluble salts are lacking in the lower part of the profile of the former.

Chestnut-mycelium-carbonate chernozems (Ciscaucasus "chestnut chernozems,"[4] the "chestnut chernozems" of the Rumanian soil scientists), which are analogous to the southern chernozems.

The question of whether to differentiate a fifth subgroup of "podzolized deep-mycelium chernozems" is still not clear and requires further study. A brief description of the diagnostic features of the chernozem subgroups in the Western facies group, based on data from the Ciscaucasus provinces, is given below.

The deep-mycelium (Ciscaucasus leached) chernozems are characterized by the dark gray color of the A horizon, a brownish-cinnamon B horizon and a brownish-pale yellow C horizon. The A horizon has a blocky-granular friable structure, whereas the B horizon has a granular-blocky structure and is somewhat weakly solidified. They are characterized as well by effervescence at great depth -- 100-175 cm -- and precipitation of the carbonates as veinlets and as rare white flecks below 150-200 cm. The carbonate veinlets overlap into the white fleck horizon. Aeration is not intensive; occasional worm and rodent holes descend to about 200 cm. The thickness of the humus horizon reaches 150-175 cm, and the humus content in the upper, 0-10 cm layer ranges from 3 to 8%. The total humus content in the humus horizon is 50 kg per 1 m² in the Ciscaucasus chernozems and decreases to 30 kg per 1 m² in the Danube area chernozems.

The mycelium-carbonate (slightly leached) chernozems have a very dark-gray-colored humus A horizon, and a brownish-gray B horizon; the humus color extends to a depth of 150-160 cm. The texture of the A horizon is very clearly granular, that of the B_1 horizon is nutlike-cloddy, and that of the B_2 horizon is blocky-nutlike and blocky. The soils effervesce to depths of 30-60 cm. At almost the same depth one encounters carbonate separation, first in the form of encrustations and lower down as veinlets; the white specks are not dense, beginning with depths of 140-175-200 cm. The carbonate veinlets also overlap into the white fleck horizon. There is fairly intensive aeration; the worm holes, tarantula tunnels, beetle cavities, caprolites and rodent holes penetrate to a depth of 140-170 cm or more. The thickness of the humus horizon (A + B) is about 140 cm, and the humus content in the 0-10 cm layer from 3 to 8%. The humus contents in the humus horizon vary from 35-60 kg per 1 m².

In the shallow-mycelium (Azov Sea area and Ciscaucasus) chernozems, the humus horizon is dark gray or brownish-gray, gradually becoming paler with depth. The soil profile is very discontinuous, masking the soil structure; there is no well-defined granularity in the humus horizons, the soil is friable with no compaction. The soil effervesces at the surface or in the upper part of the humus horizon (down to 30 cm). The carbonate segregations first take the form of encrustations (to the depth of 30-45 cm) and then of veinlets. A poorly formed white flecks appears at a depth of about 90-120 cm. The aeration of the soil is intensive, down to depths of about 120-170 cm. The humus horizon ($A + B_1$) is 80-100 cm thick in the Danube area, Azov area and Central Ciscaucasus provinces and 120-140 cm thick in the Western Ciscaucasus provinces. In the 0-10 cm layer the humus content is 3-6%. The amount of humus in the humus horizon is 30-50 kg per 1 m². Easily soluble salts have not been noted.

The chestnut-mycelium-carbonate chernozems have a dark gray humus horizon (A + B), which gradually becomes browner with depth. The structure of the A horizon is granular (when it is not masked by the activity of boring animals); a tendency toward platiness is very often observed below the surface. The structure of the B horizon is nutlike-blocky and granular-blocky; that of the C horizon is blocky. The soil effervesces at the surface. Carbonate separates into encrustations and veinlets, which often penetrate the structural units, to 30-45 cm; an ill-defined white flecks appear below 80-120 cm, and the carbonate veinlets usually do not extend this far. There is definite compaction in this horizon. Gypsum, accompanied by small amounts of easily soluble salts, is encountered at depths below

---

[4] Gavrilyuk, F. Ya. 1955. The chernozems of the Western Ciscaucasus area. Kharkov.

250-350 cm. These soils are strongly aerated by worm holes, beetle and tarantula cavities and tunnels, caprolites, rodent holes, mollusk shells, animals living on the surface, etc. The aeration is intensive down to the compact carbonate horizon (140-150 cm) and weak below this. The humus horizon (A + B) is 75-100 cm thick; below this, down to the white fleck horizon, a general very pale humus coloration is observed. In the 0-10 cm layer the humus content is 4 to 5%. The amount of humus in the humus horizon is very small -- 16-20 kg per 1 m^2. The chestnut-mycelium-carbonate chernozems of the Central Ciscaucasus province have a three-part profile: a non-saline horizon above, the slightly solonetz-like horizon (the compact carbonate horizon contains a concentration of alkali from the normal carbonates), and below this a salt horizon. This category includes S. S. Neustruyev's "Ciscaucasus low-humus chernozems."[5]

In distinguishing the genera within the subgroups described previously, we have been guided by the same principles they had adopted for the chernozems of the Central facies group. One peculiar genus that has been noted is that of the "fused" chernozems, whose genesis is not completely clear; a number of investigators think that they have been affected in the past by forest vegetation.

The basic species are grouped in three main provinces: the Danube area, the Western Ciscaucasus and the Central Ciscaucasus. The last of these also includes part of the chernozems in the eastern part of the Azov Sea area and extends eastward to the Terek River.

Chernozem Subgroups of the Eastern (East Asian) Facies Group. Investigations in recent years have shown that the eastern part of the chernozem zone, in the Transbaykal area and northeastern China, is essentially different in regard to both soil genesis and agriculture from the other parts, and may thus be considered as a special facies with its own chernozem soil subgroups.

Study of the chernozems of this facies was begun in his own time by L. I. Prasolov,[6] who noted their many peculiarities; he did not, however, stress their right to belong to a special facies to the same degree as he did in the case of the chernozems of the Sea of Azov area. This has been done by the recent work of both Soviet and Chinese scientists. Since very little of the material of these recent investigations has yet been published, only a very brief review of the chernozems of the Eastern facies is given below.

The Eurasian chernozem zone is very narrow in the east, because of the rapid increase in arid conditions as one moves from the taiga and forest regions toward the semi-deserts of Central Asia; therefore the division of the chernozems into subgroups is here relatively indistinct.

In the northern part of the zone, where the long seasonal freezing of the soil is maintained to the end of summer, a peculiar kind of "chernozem-like meadow-frozen soils" without a carbonate horizon has been noted;[7] these evidently must be considered as belonging within the chernozem soil group. Their position in the genetic classification of soils has not yet been established.

Farther south, within the well-drained plains and foothills, two chernozem subgroups have been distinguished: one with a somewhat greater amount of humus in the soil profile (20-25 kg per 1 m^2) and called "ordinary eroded" or "medium," and the second with a very small amount of humus (15-20 kg per 1 m^2), called "southern eroded" or "poor." These names are temporary and conditional. The latter subgroup borders on the chestnut soils. Both the subgroups named previously are characterized (according to data from N. A. Nogina and K. A. Ufimtseva) by: 1) a low humus content (4 to 6%), 2) low (and more rarely medium) thickness (A + B = 50 cm); the main part of the root mass is in the 0-25 cm layer, below which the content of roots and humus falls sharply, 3) the easily soluble salts and gypsum leached from the soil profile, 4) occurrence of calcium carbonate at various depths, as a rule below the humus horizon. Westward, in the Transbaykal province, the carbonate horizons are distinctly marked by whitish mycelium-like segregations and encrustations on pebbles, with the greatest content of carbonates in the upper part of the horizon. Eastward, in the East Asian or Dunbey province, the carbonate horizons are less distinct. Their fullest extent may most often be seen in soils with sandy and gravel interbeds or those underlain by old products of weathering. The carbonates take various forms: mycelium-like segregations, encrustations on rock fragments and pebbles, and in places by pseudo-mycelia (the meadow-chernozem soils found among the Dunbey chernozems are often rich in mycelia and sometimes effervesce at the surface).

---

[5] Neustruyev, S. S. and Ye. N. Ivanova. 1926. The soils of the Mozdok steppe. Trudy Sev.-Kavk. Assots. Issled. Inst., No. 17. Rostov-on-Don.

[6] Prasolov, L. I. 1927. The southern Transbaykal area an outline of the soil geography . OKISAR Akad. Nauk SSSR, Leningrad.

[7] Kovda, V. A., Yu. A. Liverovskiy and Sun Da-chen. 1957. A brief sketch of the soils in the Amur River area. Izv. Akad. Nauk SSSR Ser. Biol. No. 1.

Up to the present time the following generic chernozem subdivisions have been observed in the Eastern facies of the chernozem zone: residual solonetz-like, residual carbonate, "deep-effervescing" and "non-carbonate."

A neutral or weakly alkaline reaction is usual in the sub-humus horizons lacking in carbonates of the "deep-effervescing" and "non-carbonate" chernozems, which must not be confused with the leached chernozems.

There is no great variety of species in the chernozems of the Eastern facies, because of the small variation in the biological accumulations. Low-humus chernozems predominate, weakly humic chernozems are often encountered (in the Dunbey) and medium-humus chernozems very rarely. Thin chernozem is typical (to 40 cm), but medium-thickness chernozems have been encountered.

It is impossible at the present time to present a full systematic classification of the chernozem subgroups of the Eastern facies group, but the sources that have been cited should be studied in classifying the chernozems of the other facies groups.

Received June 18, 1958

SEASONAL CHANGES IN COMPOSITION OF ORGANIC MATTER IN DRAINED, CULTIVATED BOG SOILS

T. A. NIKOLAYEVA
V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

The study of the changes in the organic matter of the soil is still in its initial stages. The literature includes few papers devoted to investigations of seasonal changes in the amount of forest litter, the total content of humus and nitrogen in soils, and the changes in the amounts of water-soluble organic substances (1, 3, 10, 11, 12).

There are still very few data on the seasonal changes in the quantitative composition of the humus. Recent investigations of the problem have been made by a group of co-workers in the Leningrad Agricultural Institute (Aleksandrova, Naydenova and Shumakova, 2; Kashchenko, 4), in relation to the sod-podzolic clay loam soils of the Leningrad Oblast'.

This paper presents the results of a study of seasonal changes in the qualitative composition of the organic matter in the drained, cultivated bog soils of the Moscow Oblast' bog experimental station, situated 80 km from Moscow on the left bank of the Yakhroma River. A description of the geology, geomorphology and soils in the area of the station may be found in the article by Skrynnikova (10). The present author limits herself to showing that the station's soils have become familiar to soil scientists over the past 20 to 25 years, and that the crops are predominantly perennial grasses. The investigations described here were made on the following soils:

1. Section 54. Alluvial bog soil and clay-peaty soil on sedge-and woody-peat. Located in the channel area of the flood-plain.
2. Section 56. Humus-peat, iron-bearing soil on grassy-wood peat (alder trees). Located in the central part of the flood-plain.
3. Section 58. Humus-peaty, iron (carbonate soil on thick sedge-peat. Located in the terraced part of the flood-plain.

All these soils are distinguished by their high ash content, especially the clay and best-drained soil of Section 54. The first two soils are characterized by the high degree of decomposition of the peat, especially in the plowed horizon. The third soil is characterized by a lower degree of peat decomposition, a high degree of carbonate formation and lower vegetative yields.

Soil samples were taken for study of the qualitative composition of the organic matter in 1956 on the following dates: April 13, June 20, August 5 and October 3. The specimens were removed with a Nekrasov drill from the depths of 0-10 cm and 30-40 cm, replicated three times so that each replication consisted of ten individual holes in the experimental area. After the samples were removed, the holes were filled up with peat taken for this purpose from the edges of the drainage ditch.

The specimens were analyzed in their fresh -- that is, undried -- condition. To free them of plant roots and to obtain homogeneous specimens, the soils were passed through aluminum sieves with openings of 2-3 mm and then thoroughly mixed. First, the approximate moisture content was estimated, in order to take out a portion of soil corresponding to about 5g of dry matter. Then, from the specimens prepared for analysis, portions were determined for the composition of the organic matter and for a repeated, accurate determination of the moisture content.

The composition of the organic matter was analyzed by I. V. Tyurin's quick method (8, 9, 16), which makes it possible to subdivide the humus substances into those soluble in 0.1 N NaOH before and after decalcification.

The analytic procedure was as follows:

1. The portions of soil were steeped in 200

ml of 0.1 N H_2SO_4 (in the case of the carbonate peat of No. 58, in 0.1 N HCl) for twenty-four hours; then the calcium was removed with water weakly acidified with H_2SO_4, and finally with pure water. The C and N in the extract were determined by Tyurin's method.

2. After this the same portions were steeped for twenty-four hours in 400 ml of 0.1 N NaOH. The following day 100 ml of a saturated solution of Na_2SO_4 were added to flocculate the mineral colloids, and the extract was filtered through a paper filter. The residues of soil were washed in a 0.1 N solution of Na_2SO_4 until the filtrate was almost colorless. In the alkaline extract the total content of C and N and of the C and N in the humic acids was determined; the C and N content in the fulvic acids was calculated by the difference between the C and N in the original alkaline filtrate and in the humic acids.

3. An alkaline extract was prepared in the same manner from the now decalcified soil, and the figures from the analysis of this extract were subtracted from the totals of the figures for the analysis of the acid (0.1 N H_2SO_4) extract and the succeeding alkaline (0.1 N NaOH) extract.

The difference obtained corresponded to the content of the more stably bonded humic acids and fulvic acids in the soil.

Seventy-two soil specimens were analyzed, allowing for the three replicates for range, in carrying out this work. For each of these about 20 analytic determinations were made; these in turn involved two or three replications. The seasonal differences in the analytic data were always greater than the largest fluctuations between the range and the analytic repetitions.

Before examining the figures for the analyses, it will be well to review briefly the conditions in the year 1956 in the region under investigation. Meteorological observations at the experimental station show that the cold spring with a small amount of precipitation was followed in June by warm, dry weather with average monthly air temperatures of about 20° C. Approximately the same weather conditions were observed in July and August: the temperature fell to about 15° C, however, and the amount of precipitation increased twice as compared to that of June. Cool weather with a small amount of precipitation prevailed in September. The temperature curve for the vegetation period of 1956 is given below, in one of the graphs, and data soil moisture in the field are given in one of the tables.

The results of the experiments are set forth below.

SEASONAL CHANGES IN THE TOTAL CONTENT OF C and N AND IN THE CONTENT OF THE ELEMENTS IN THE ORGANIC MATTER

An average soil sample was thoroughly dried in air, pulverized in a mortar and passed through a sieve with 0.25 mm openings. Content of hygroscopic water, ash, C and N were determined and the approximate amounts of the elements in the organic matter were calculated.

To determine the total amounts of C and N, 0.2-gram portions of peat were oxidized in a Knopp apparatus with a 3.0 N solution of CrO_3, with a 3:2 ratio of H_2SO_4:H_2O and with a Ag_2SO_4 catalyst. The carbon dioxide content was determined both by the gravimetric method (C_{CO_2}) and by the oxidizing capacity (C_{O_2}); for the same purpose the remaining amount of oxidizing agent was reduced to a definite volume, from which two or three parallel samples were taken for titration with Mohr's salt. The ammonium was driven off from two other aliquot samples of the same solution, for the determination of the nitrogen content (for a more detailed description of the method of simultaneously determining C_{CO_2}, C_{O_2} and N see the article by Ponomareva and Nikolayeva, 9).

The data from the determinations of the ash content in the peat (and of the CO_2 in the carbonates of the carbonate peat samples) and of the content of C_{CO_2}, C_{O_2} and N served as the basis for calculating the approximate contents of the elements in the organic matter, using the method employed by Stanek and Nemets and subsequently by Tyurin (14) and others (9).

Table 1 shows the data on the seasonal changes in the field and hygroscopic moisture in the soil samples, the content of C and N in them and the approximate amounts of the elements in the organic matter. These data reveal a considerable seasonal fluctuation in the field moisture of the soils, the minimum of which occurs in the warmest month, June. The seasonal changes in all the other properties represented in the table are small and irregular, so that they must be attributed to the lack of uniformity of the soil samples and to the allowable margin of inaccuracy in the analyses.

In recomputing the data on C and N for water-free and ash-free organic matter, the seasonal differences between them are leveled down still more. The calculated composition of the elements of the organic matter in the very same peat specimens remains practically constant through the vegetative period. The only differences observed were those between the various specimens of peat. Thus, for instance, in all the soils investigated by the

Seasonal changes in the content of organic matter and of the elements in its composition
(averages of three determinations)

Section No.	Depth, cm	Observation dates	% absolutely dry matter								%water-free and ash-free organic matter				Ratios		
			Field moisture	Hygroscopic water	CO_2 in carbonates	Ash	Organic matter	C_{CO_2}	C_{O_2}	N	C	H	O	N	C:N	C:H	O:H
54	0—10	April	100	10,4	—	52,4	47,6	24,5	24,6	1,56	51,4	5,7	39,6	3,3	15,7	9,0	7,0
		June	49	10,5	—	55,8	44,2	22,4	22,3	1,39	50,7	5,7	40,5	3,1	16,1	8,9	7,1
		August	131	10,6	—	54,7	45,3	22,9	22,9	1,37	50,6	5,7	40,7	3,0	16,7	8,9	7,1
		October	123	10,2	—	55,7	44,3	22,2	22,3	1,45	50,2	5,8	40,7	3,3	15,3	8,7	7,0
		Average	—	10,4	—	54,7	45,3	23,0	23,0	1,44	50,7	5,7	40,4	3,2	15,9	8,9	7,0
	30—40	April	199	14,9	—	24,4	75,6	41,3	41,3	2,00	54,6	5,3	37,4	2,7	20,6	10,3	7,1
		June	192	15,3	—	23,1	76,9	41,7	41,7	2,06	54,2	5,3	37,8	2,7	20,2	10,2	7,1
		August	285	14,9	—	25,8	74,2	39,4	39,9	1,76	53,0	5,6	39,0	2.4	22.4	9,5	7,0
		October	277	14,9	—	23,5	76,5	42,0	41,8	1,76	54,8	5,2	37,7	2,3	23.9	10,5	7,2
		Average	—	15,0	—	24,2	75,8	41,1	41,2	1,90	54,2	5,3	38,0	2,5	21,8	10,1	7,1
56	0—10	April	204	14,0	—	38,5	61,5	30,9	31,2	2,00	50,3	5,9	40,5	3,3	15,4	8,5	6,9
		June	102	14,8	—	39,6	60,4	30,3	30,6	1,98	50,1	5,9	40,7	3,3	15,3	8,5	6,9
		August	203	14,4	—	38,4	61,6	31,5	30,9	2,05	51,1	5,4	40,2	3,3	15,4	9,4	7.4
		October	199	14,2	—	38,8	61,2	31,0	30,5	2,08	50,7	5,5	40,4	3,4	15,0	9,2	7,3
		Average	—	14,3	—	38,8	61,2	30,9	30,8	2,03	50,5	5,7	40,5	3,3	15,3	8,9	7,1
	30—40	April	342	15,6	—	18,9	81,1	44,0	44,0	2,85	54,2	5,4	36,9	3,5	15,4	10,0	6,8
		June	270	15,3	—	13,1	86.9	46.3	46.9	3,03	53,3	5,7	37.5	3,5	15.3	9,4	6,6
		August	421	15,7	—	17,5	82,5	44,2	44,9	2,96	53,6	5,7	37,1	3,6	15,0	9,4	6,5
		October	466	14,3	—	14,2	85,8	46,5	46,9	3,01	54,2	5,5	36,8	3,5	15.4	9.8	6.7
		Average	—	15,2	—	15,9	84,1	45,3	45,7	2,96	53,8	5,6	37,1	3,5	15,3	9,6	6.6
58	0—10	April	328	9,2	16,6	40,5	42,9	21,3	21,3	1,60	49,6	5,9	40,8	3.7	13,3	8.4	6,9
		June	129	9,1	16,5	41,9	41,6	20,5	20,5	1,58	49,3	5,9	41,0	3,8	13,0	8,4	6,9
		August	233	9,4	16,8	39,4	43,8	21,7	21,7	1,70	49,5	5,9	40,7	3,9	12,8	8,4	6,9
		October	237	9,3	17,2	39,1	43,7	21,7	21,6	1,66	49,5	5,8	40,9	3,8	13.1	8,5	7,0
		Average	—	9,3	16,8	40,2	43,0	21,3	21,3	1,63	49,5	5,9	40.8	3,8	13.1	8.4	6,9
	30—40	April	388	11,2	10,3	29,5	60.2	31.5	31,5	2,13	52,3	5,6	38.6	3,5	14.8	9,3	6,9
		June	218	11,0	14,7	26,3	59,0	31,6	31,6	2,01	53.5	5,4	37,7	3.4	15.7	9,9	7,0
		August	332	11,5	13.1	25,7	61,2	32,4	32,2	2,13	53,0	5,4	38,1	3,5	15,2	9,8	7,1
		October	335	11,6	12,4	25,2	62,4	32,5	32,5	2,00	52,1	5.6	39,1	3,2	16,2	9.3	7.0
		Average	—	11,3	12.6	26,7	60,7	32,0	31,9	2,07	52,7	5,5	38.4	3.4	15.5	9,6	7,0

Comma represents decimal point.

author the organic matter in the 30-40 cm layer is richer in carbon than the organic matter from the depth of 0-10 cm. These differences may be explained, however, by the higher ash content of the peat in the 0-10 cm layer; this somewhat decreases the accuracy of the determination of the organic substances by loss through ignition, resulting from the effect of the chemically bonded water.

It should be pointed out that in the soils investigated, the amounts of C as obtained by the gravimetric method and by the oxidation capacity turned out to be very close. This characterizes the organic matter in the peat as being "normally" oxidized -- that is, having a ratio of hydrogen to oxygen close to 2H:O. No regular seasonal changes in the degree of oxidation of the organic matter have been noted.

The data from the determinations of the qualitative composition of the organic matter, on the same dates, are discussed below.

SEASONAL CHANGES IN THE TOTAL AMOUNTS OF ORGANIC C AND N DISSOLVED DURING THE SUCCESSIVE TREATMENT OF THE SOILS WITH 0.1 N H_2SO_4 (or HCl) and 0.1 N NaOH.

Considerable seasonal changes have been noted (Table 2) in the group composition of the organic matter in the peat-bog soils. There is a regular pattern of changes in the total amounts of organic C and N dissolved in the successive treatment of the soils with 0.1 N H_2SO_4 (or HCl) and 0.1 N NaOH. Figure 1 shows that the curves of the total amounts of C and N dissolved reveal different seasonal changes in the various horizons of the peat soils. At the depth of 0-10 cm they are generally directly related to the temperature curves, and show a maximum on the warmest day in June. At the depth of 30-40 cm the solubility of the organic matter shows no correlation with either the temperature or the field moisture in the soils; the solubility decreases from spring to autumn. It is interesting to note that at the depth of 0-10 cm the mobility of the nitrogen is much greater than that of the carbon, whereas at the depth of 30-40 cm they both have approximately the same mobility.

The increased solubility of the organic matter of the peat in the 0-10 cm layer in June may be associated with the increased temperature on this date and the fact that the soil moisture approaches optimal conditions; this should, on the one hand, intensify the microbiological processes and the formation of new, relatively soluble humus substances. On the other hand, the increase in the temperature, along with the maintenance of a fairly large amount of moisture in the peat, will of course have direct effect on the colloidal and chemical state of the humus substances, giving rise to processes of hydrolysis, peptization, etc. Probably both of these effects are interdependent. During this period there is apparently also an increase in the mineralization of the organic matter, as has been noted by numerous investigators in the case of mineral soils. In peat soils, however, because of the high content of organic matter, its consumption in the mineralization processes in individual seasons of the year can hardly be detected analytically -- that is, from the data on the determination of the total amount of C (see Table 1).

The seasonal changes in the solubility of the organic matter in the peat at the depth of 30-40 cm cannot be explained by the effect of the microbiological processes. They are completely independent of the changes in the air temperature and the moisture in the soil and are determined mostly by colloidal-chemical processes such as the stable flocculation of humus colloids, aging and so forth. It may be assumed that analogous colloidal-chemical changes, tending toward a decrease in the mobility of the humus substances, also take place in the 0-10 cm layer during the period following the maximum mobility,[1] from July to October. Figure 1 shows that after June the solubility of the organic matter diminishes not only in the 30-40 cm but also in the 0-10 cm layer.

Confirmation of the fact that the seasonal changes in the organic matter of peat-bog soils are due not only to biological but also, and apparently for the most part, to colloidal-chemical processes may be found in the seasonal changes in that part of the organic matter that goes into solution in this method of analysis.

The nature of these changes may be seen in Table 2 and Figure 2.

Fraction 1a, soluble directly in 0.1 N H_2SO_4 (or HCl). In spite of the generally small amounts dissolving in solution and the low seasonal variation of this fraction, one may observe a sharp decrease in the C:N ratio in its composition in August; this is especially characteristic of the upper horizon of peat

---

[1] In saying that the greatest mobility of the organic matter is in the June period, the author is well aware that this refers to the maximum as calculated. It is possible that a still greater maximum of mobility may have occurred somewhat before or after June 20 -- the data on which the samplings were taken. This could be determined accurately only by means of continuous observations.

Table 2

Seasonal changes in the group and fractional composition of the organic matter as percentages of the total content of C and N in the soil (averages of three determinations)

Section No.	Depth, cm	Observation dates	Soluble in 0.1 N H_2SO_4 (fraction 1a)			Soluble directly in 0.1 N NaOH (fraction 1				Soluble in 0.1 N NaOH only after decalcification (fraction 2)				Total of soluble substances										Insoluble residue (difference)		
														total			humic acids			humic acids						
			C	N	C:N	total C	C in humic acids	C in fulvic acids	humic acids / fulvic acids	total C	C in humic acids	C in fulvic acids	humic acids / fulvic acids	C	N	C:N	C	N	C:N	C	N	C:N	humic acids / fulvic acids	C	N	C:N
54	0—10	April	1,8	1,8	16,1	30,6	19,6	11,0	1,8	5,0	4,9	0,1	49,0	37,4	44,0	13,4	24,5	24,2	15,9	12,9	19,8	10,3	1,9	62,6	56,0	17,5
		June	1,9	1,9	15,6	39,3	22,3	17,0	1,3	6,5	6,5	0,0	∞	47,7	59,5	12,9	28,8	32,9	14,1	18,9	26,6	11,4	1,5	52,3	40,5	20,8
		Aug.	1,6	2,8	9,7	32,6	23,9	8,7	2,8	10,6	2,7	7,9	0,3	44,8	54,7	13,7	26,6	30,4	14,6	18,2	24,3	12,5	1,5	55,2	45,3	20,4
		Oct.	1,7	1,7	15,8	31,9	18,9	13,0	1,5	6,7	5,6	1,1	5,1	40,3	43,2	14,3	24,5	25,0	15,0	15,8	18,2	13,4	1,5	59,7	56,8	16,1
	30—40	April	1,0	1,2	17,9	33,0	20,7	12,3	1,7	8,1	6,8	1,3	5,2	42,1	43,1	20,2	27,5	28,0	20,3	14,6	15,1	20,0	1,9	57,9	56,9	21,0
		June	0.9	1,3	14,4	29,4	16,8	12,6	1,3	9,3	7,9	1,4	5,6	39,6	41,2	19,4	24,7	25,9	19,3	14,9	15,3	19,7	1,7	60,4	58,8	20,8
		Aug.	0,9	1,5	12,1	23,0	16,6	6,4	2,6	9,7	4,1	5,6	0,7	33,6	35,4	21,2	20,7	22,0	21,1	12,9	13,4	21,5	1,6	66,4	64,6	23,0
		Oct.	0,9	1,2	17,6	18,8	10,9	7,9	1,4	8,8	7,6	1,2	6,3	28,5	30,1	22,5	18,5	19,8	22,3	10.0	10,3	23,0	1,9	71,5	69,9	24,4
56	0—10	April	1,4	1,5	15,1	31,8	18,7	13,1	1,4	1,3	1,3	0,0	∞	34,5	39,8	13,4	20,0	21,1	14,6	14,5	18,7	12,0	1,4	65,5	60,2	16,8
		June	1,4	1,5	14,8	39,3	21,8	17,5	1,2	2,8	2,3	0,5	4,6	43,5	50,8	13,1	24,1	27,9	13,2	19,4	22,9	13,0	1,2	56,5	49,2	17,5
		Aug.	1,3	1,9	10,5	33,2	22,3	10,9	2,0	5,7	0,0	5,7	0,0	40,2	46,5	13,3	22,3	25,9	13,2	17,9	20,6	13,3	1,2	59,8	53,5	17,2
		Oct.	1,4	1,3	15,0	30.1	17,0	13,1	1,3	4,1	2,5	1,6	1,6	35,6	36,8	14,4	19,5	20,8	14,0	16,1	16,0	14,9	1,2	64,4	63,2	15,2
	30—40	April	0,8	1,0	12,5	31,4	21,2	10,2	2,1	4,7	3,8	0,9	4,2	36,9	36,2	15,7	25,0	23,8	16,2	11,9	12,4	14,8	2,1	63,1	63,8	15,3
		June	0,6	1,0	10,0	28,1	17,1	11,0	1,5	5,7	4,0	1.7	2,3	34,4	34,9	15,1	21,1	20,8	15,5	13,3	14,1	14,5	1,6	65,6	65,1	15,4
		Aug.	0,7	1.0	10,0	26,2	19,4	6,8	2,9	4,0	0,7	3,3	0,2	30,9	31,9	14,5	20,1	20,2	14,9	10,8	11,7	13,8	1,9	69,1	68,1	15,1
		Oct.	0,7	0,7	15,4	18,4	11,4	7,0	1,6	6,6	6,6	0,0	∞	25,7	25,5	15,6	18,0	17,8	15,6	7,7	7,7	15,5	2,3	74,3	74,5	15,4
58	0—10	April	3,0	2,3	17,3	12,3	5,2	7,1	0,7	15,4	9,1	6,3	1,4	30,7	32,7	12,5	14,8	14,9	13,2	15,9	17,8	11,9	0,9	69,3	67,3	13,7
		June	2,9	2,4	15,8	11,6	5,2	6,4	0,8	18,7	10,0	8.7	1,1	33,2	36,6	11,8	15,2	16,9	11,7	18,0	19,7	11,9	0,8	66,8	63,4	13,7
		Aug.	3,1	3,0	13,1	12,5	5,8	6,7	0,9	16,4	9,1	7,3	1,2	32,0	34,1	12,0	14,9	16,0	11,9	17,1	18,1	12,0	0,9	68,0	65,9	13,2
		Oct.	2,9	2,4	16,4	9,8	4,6	5,2	0,9	17,5	9,2	8,3	1,1	30,2	30,1	13.1	13,8	14,4	12,6	16.4	15,7	13,7	0,8	69,8	69,9	13,0
	30—40	April	1,1	1,0	17,1	11,6	4,7	6,9	0,7	13,4	8,6	4,8	1,8	26,1	26,6	14,5	13,3	13,6	14,4	12,8	13,0	14,6	1,0	73,9	73,4	14,9
		June	1,1	1,1	15,5	8,8	4.2	4,6	0,9	10,0	6,0	4,0	1,5	19,8	21,8	14,3	10,1	11,4	14,0	9,7	10,4	14.5	1,1	80,2	78,2	16,1
		Aug.	1,0	1,6	9,1	8,1	3,9	4,2	0,9	10,0	5,6	4,4	1,3	19,1	20,0	14,5	9,5	10,4	13,8	9,6	9,6	15,2	1,0	80,9	80,0	15,4
		Oct.	0,9	0,9	16,7	7,6	3,6	4,0	0,9	9,5	5,4	4,1	1,3	18,0	18,5	15,8	9,0	9,6	15,3	9,0	8,9	16,3	1,0	82,0	81,5	16,3

Comma represents decimal point.

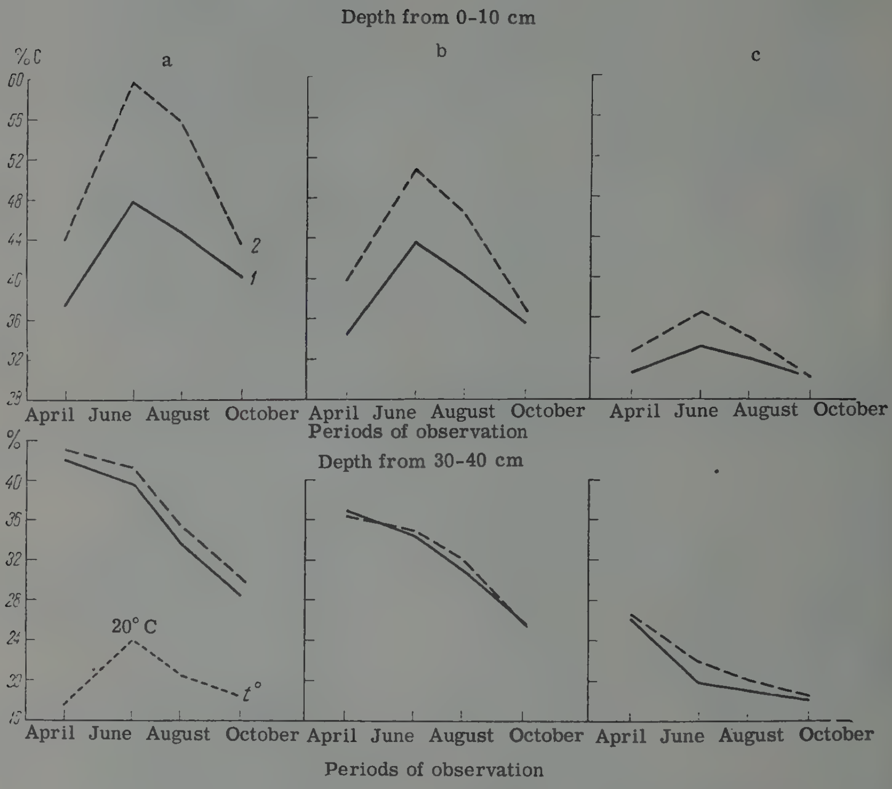


Fig. 1. - Seasonal changes in the total amounts of C and N dissolving in solution (0.1 N $H_2SO_4 \rightarrow$ 0.1 N NaOH), as percentages of the total content of C and N:

a - soil 54; b - soil 56; c - soil 58. 1 - amount of C dissolving in solution; 2 - amount of N dissolving in solution.

Fraction 1, soluble directly in 0.1 N NaOH (after deducting fraction 1a). The total content of this fraction, which is quantitatively predominant in the peat samples studied here, changes on the dates of observation in the same manner as the total amounts of C and N dissolving in solution. In the 0-10 cm layer the greatest amounts of this fraction in solution are in June, whereas in the 30-40 cm layer this diminishes gradually from spring to autumn.

On all the dates of observation humic acids predominate over fulvic in the composition of this fraction, but the relationship between these changes with the seasons. The relative content of the humic acids in this fraction is lowest in the period when the mobility of the organic matter is greatest, in June. By August there are sharp changes in the composition: the fulvic acid content decreases and the humic acid portion increases, so that the humic-to-fulvic-acid ratio is increased by two and a half times, as compared to the other dates. Since this is observed not only in the biologically active 0-10 cm layer, but at the depth of 30-40 cm as well, it is obviously caused by some factor common to both layers -- above all, by changes in the colloidal-chemical condition of the humus substances. These changes may be considered generally as a late-summer "aging" of the early-mobilized humus substances. It may be assumed that they are repeated each year approximately at the time when the annual vegetation matures.

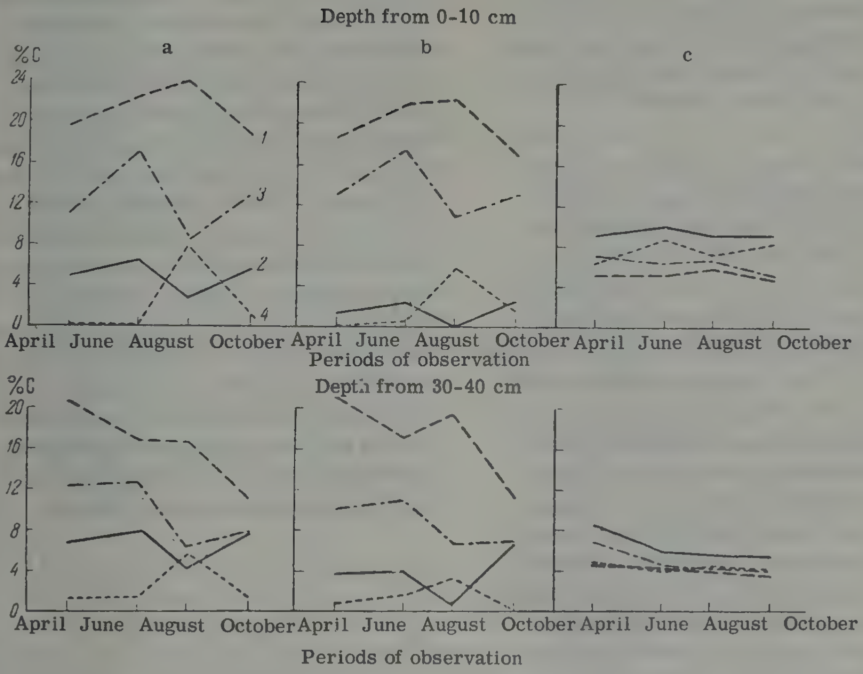


Fig. 2. - Seasonal changes in the group composition of the soluble part of the organic matter, as a percentage of the total content of C:

a - soil 54; b - soil 56; c - soil 58. 1 - humic acid in fraction 1; 2 - humic acid in fraction 2; 3 - fulvic acid in fraction 1; 4 - fulvic acid in fraction 2.

The characteristic changes that occur in the composition of the mobile fraction of the humus substances during August are also reflected in changes in the composition of the other, more stable fraction, which is soluble in 0.1 N NaOH only after decalcification.

Fraction 2, soluble in 0.1 n NaOH only after decalcification. Whereas the greatest amount of fraction 1 going into solution is in June, the soluble portion of fraction 2 is greatest in August. In August there is probably a partial transition of fraction 1 into the more stable fraction 2, along with a general diminishing of the solubility of the organic matter in the peat. Great seasonal changes in the ratio of humic to fulvic acids are typical of fraction 2. On all the dates of observation, except for August, this fraction has a considerable predominance of humic over fulvic acids, which in a number of cases may even be lacking. In August the relationship between them changes sharply, through an increase in the content of fulvic acids and a decrease in that of the humic acids, until the latter almost completely disappear.

Thus in August there are completely opposite changes in the group composition of the organic matter in peat soils. The overall result of these changes is a partial transition of the humic acids in fraction 2 to an insoluble state during this method of analysis, and transformation of the more mobile fulvic acids of fraction 1 into the less volatile fraction 2. A seasonal mutual transition is possible, moreover, between the group of humic acids and that of the fulvic acids. No exact quantitative proportional relationship has been noted, however, between the decrease in one fraction and the increase in the other.

Figure 2 clearly shows the complex but regular seasonal regrouping of the fractions in the composition of the soluble part of the organic matter in peat soils. Along with the seasonal interchanges of the fractions, toward autumn there is a gradual transition of the whole system of humus substances into more stable forms.

In October in the 0-10 cm layer, the position of almost all the curves relative to the ordinate becomes about the same as at the beginning of the annual cycle in April. This regularity does not appear in the 30-40 cm layer, since here, beginning with April, there is a general lowering of the solubility of the organic matter. Unfortunately these observations were made only during a single year, so that it remains unknown where the curve of the amounts of C and N going into solution in the 30-40 cm layer would begin if the observations were continued into the following year. It is hard to believe that this would become lower and lower from year to year. More likely, as a result of the conditions of the long winter period (for example, repeated freezing and thawing), the organic matter in the 30-40 cm layer would return to approximately the same state in which it was in the spring of the preceding year, especially if one disregards the apparently negligible irreversible changes taking place each year in the composition of the organic matter of this layer. Whether this is actually the case, however, still remains to be seen.

It should be noted that the seasonal changes in the curves for the same fraction are, in general, similar in both layers. The exception is the curve for the humic acids of fraction 1, which shows different changes at the depths of 0-10 and 30-40 cm. The repetition in the shapes of the curves in the case of the first two soils investigated (Sections 54 and 56) indicates the reliability of these data.

As regards the third soil -- the slightly decomposed carbonate peat of Section 58 -- this has scarcely been taken into account in judging the results. This soil is interesting in that it shows very little amplitude in the monthly changes in the group composition of the organic matter. It is possible that the constant enrichment of this soil with calcium carbonate from the ground waters tends to preserve the organic matter in the peat. This is manifested first of all in the slight mobility of the organic matter in the month of June; and because of the lack of sufficient mobile organic matter the changes on the succeeding dates are also very small.

It may be assumed that the mobility of the organic matter increases in the first half of the vegetative period not only in peat but also in other soils as well. Ponomareva's data,[2] for instance, show a similar seasonal change in the solubility of the humus in 0.1 N H_2SO_4 and 0.1 N NaOH in the Kursk chernozem (Fig. 3). This phenomenon is possibly of significance in the growth of vegetation, not only indirectly, by facilitating the processes of mineralization and freeing of the ash elements and nitrogen, but also directly, by stimulating biological activity. The direct positive effect of solutions of humus substances as growth stimulators has been proved by many investigators (5, 17). In the light of these investigations, it is interesting to note that in nature the increase in the solubility of the humus substances coincides exactly with the period of maximal growth, whereas in the period of maturation of the plants the solubility of the humus substances decreases. This fact is of great importance in that artificial means of stimulating the biological growth of vegetation are rarely used, in the first place; in the second place, their action can scarcely compare with the manifold effects of natural biological stimulating processes when the soil contains sufficient amounts of organic matter and the conditions favor these processes.

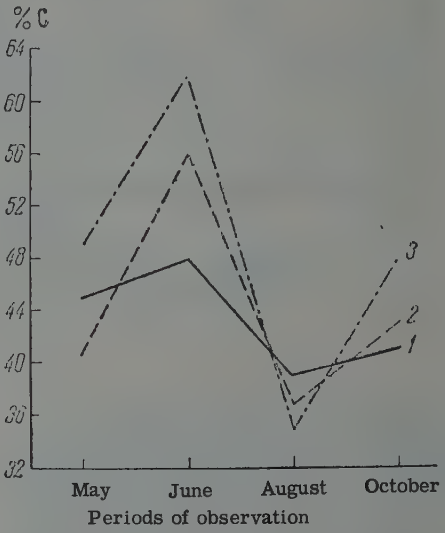


Fig. 3. - Seasonal changes in the total amounts of the organic C in the chernozems that dissolves in solution (0.1 N H_2SO_4 → 0.1 N NaOH), as percentages of the total content of C.

1 - 0-5 cm depth, 2 - 5-10 cm depth, 3 - 10-20 cm depth.

Only a few dates of observation are included, because of the great detailed analytical work.

---

[2] These data have not been published.

Ultimately, in investigating the changes in the composition of the organic matter in soils, it will be necessary to increase the frequency of he observations, so as to obtain a picture of hese dynamic aspects through analysis that s as close as possible to the actual one -- . e., to find the true amplitude of the seasonal changes in the organic matter, to make hem more precise and to extend them in time n association with the growth of plants, the activity of microorganisms, the relationship o the changing weather conditions, etc.

The fairly great seasonal changes in the composition of the organic matter in soils suggest the question: would it be more profitable to study this at any particular, static moment, as is done in comparative geographical soil investigations, and if so, on what specific date? The first question cannot be answered negatively, since data obtained on different days and even in different years on the composition of the humus in various soil groups and subgroups (5, 7, 13, 15) reflect essential and regular differences in these soils. This shows that in spite of seasonal changes in the soil properties, there is a definite and constant regularity in these indices and properties which is not obscured by the seasonal changes. Within regions and areas with more or less similar climatic conditions, however, it would probably be better to adhere to the possibility of taking more frequent soil samples to study the content and composition of the humus in them. In regard to the dates on which such samples should be taken, the data obtained suggest that these should be during the period of maximal mobility of the organic substances (the end of June, in the soils investigated here), when the individual peculiarities of the soils will be most apparent; this period is also very important in the life of the vegetation, since it is the time of greatest growth and greatest consumption of nutrient and stimulating substances.

It must be recalled, however, that the data in this article refer to fresh, non-dried soil specimens, whereas in the static study of soils air-dried specimens are usually analyzed. Therefore, before drawing any final conclusions on the best dates for taking specimens, comparative data are needed on the changing compositions of the organic matter in both fresh and dry specimens of soil. The results of such a comparison, which are closely connected with the data in the present article, have been prepared for publication.

This paper was written under the direction of Academician I. V. Tyurin and of V. V. Ponomareva, to whom my appreciation is expressed.

BIBLIOGRAPHY

1. ABRAMOVA, M. M. 1947. Seasonal changes in some chemical properties of forest podzolic soils. Trudy Pochv. In-ta im. V. V. Dokuchayeva Akad. Nauk SSSR Vol. 25.

2. ALEXANDROVA, L. N., O. A. NAYDENOVA and M. F. SHUMAKOVA. 1956. Changes in group and fractional composition of the humus in the annual cycle of soil forming processes in sod-podzolic soils. Zapiski LSKhI, No. 11.

3. BARANOVSKAYA, A. V., A. YU. DARAGAN-SUSHCHOVA and A. M. GLOBUS. 1957. Seasonal changes in the chemical properties of some soils in the Vologda Oblast'. Pochvovedeniye No. 7.

4. KASHCHENKO, A. S. 1957. Changes in group composition of the humus of sod-podzolic soils. Zapiski LSKhI, No. 13.

5. KONONOVA, M. M. 1951. Humus in the soil and the present tasks involved in its study. Izd. Akad. Nauk SSSR.

6. KONONOVA, M. M. 1953. The humus problem in the most recent literature. Pochvovedeniye No. 12.

7. KONONOVA, M. M. 1956. The nature and formation of humus in the main USSR soil types. Pochvovedeniye No. 3.

8. PONOMAREVA, V. V. 1957. Study of humus content by I. V. Tyurin's method. Pochvovedeniye No. 8.

9. PONOMAREVA, V. V. and T. A. NIKOLAYEVA. 1958. Method of studying organic matter in peat-bog soils. Trudy Pochv. In-ta im. V. V. Dokuchayeva Akad. Nauk SSSR Vol. 56.

10. SKRYNNIKOVA, I. N. 1957. An attempt to study the soil forming processes in the improved peat-bog soils of the Moscow Oblast' bog experimental station. Trudy Pochv. In-ta im. V. V. Dokuchayeva Akad. Nauk SSSR, issue dedicated to Academician L. I. Prasolov.

11. SMIRNOVA, K. M. 1956. Seasonal changes in the soil properties of coniferous and deciduous forests. Pochvovedeniye No. 12.

12. TYULIN, A. F., S. V. KUSHNIRENKO and K. G. SHCHERBINA. 1953. The mineral nutrients of oaks and associated vegetation on dark-gray forest soils. Pochvovedeniye No. 3.

13. TYURIN, I. V. 1937. The organic matter in soils. Sel'khozgiz.

14. TYURIN, I. V. and V. V. PONOMAREVA. 1937. Data on a comparative study of the methods of determining the organic carbon in soils. Probl. Sov. Pochvoved. Sb. 4.

15. TYURIN, I. V. 1949. Geographic characteristics of humus formation. Papers of the Jubilee Session on the Occasion of the Hundredth Anniversary of V. V. Dokuchayev's Birth. Izd. Akad. Nauk SSSR.

16. TYURIN, I. V. 1951. Method of analysis in the comparative study of humus composition of soil. Trudy Pochv. In-ta im. V. V. Dokuchayeva Akad. Nauk SSSR Vol. 38.

17. KHRISTEVA, L. A. 1951. Humus fertilizers and the role of humic acids in plant nutrients. Trudy Pochv. In-ta im. V. V. Dokuchayeva Akad. Nauk SSSR, Vol. 38.

A STUDY OF THE MINOR ELEMENT CONTENTS IN SOILS OF THE AMUR RIVER AREA

V. A. KOVDA and V. D. VASIL'YEVSKAYA
Moscow State University

The Amur River basin is located in an area with a peculiar humid, monsoon, moderately cold climate. The construction of a hydroelectric station on the Amur has enabled the Soviet Union and the Chinese People's Republic to undertake extensive projects involved in developing the natural resources of the Amur River region. The great alluvial plains of the Amur River region and the taiga mountain areas of Greater and Lesser Khingan will be the sites of great new industrial centers, huge state farms and new population centers. It is known that the Amur River area contains widespread and various ancient acidic weathered crusts and podzolized, brown low-fertility forest soils. Most of the natural waters of the Amur area contain few minerals, with the result that there are frequent occurrences of goiter and abnormal development of the skeletons of men and animals, caused by mineral deficiencies.

All these facts have led us to think that the program of the series of expeditions of SOPS on the Amur should include investigations of the content of minor elements in the soils of the Amur area and a comparison of the conditions there with those in the Russian plain.[1] This article presents the results of the analysis and study of material that was collected during the field work of expeditions in 1956 and 1957. In collecting material for the investigations, we have attempted to encompass all the main geomorphologic areas of the Amur region -- watersheds, ancient terraces, floodplains -- and to investigate not only the soils but also soil forming parent materials, soil waters and certain types of local vegetation.

The manganese, chromium, vanadium, nickel, copper, barium, strontium and boron were determined by the spectrum method. The zinc, cobalt, and also copper and nickel were determined by the polarographic method. Both methods, which are used in the Department of Soil Science of the Moscow State University, are explained in papers (7) of the Interuniversity Conference on Minor Elements in the Soils of the USSR.[2]

Comparison of the results of spectrum and chemical analyses of the same specimens has shown that the correspondence of the results is fully satisfactory. The data not only fall within the limits of one order of magnitude, but are often closer. The results of the spectrum analyses may thus be considered reliable, with the assumption that the possible error does not exceed one-third of an order of magnitude.

In general, the lacustrine-alluvial and floodplain deposits are the richest in minor elements (B, V, Cr, Mn, Co, Ni, Cu, Zn, Sr, Ba). This is understandable, since the river and lacustrine alluvium of the floodplains, as well as terraces II and III, are in an area of accumulation of particles from the products of weathering and soil formation (Table 1). The smallest content of minor elements is found in such soil forming parent materials throughout the Amur area as granites and the Tertiary sands derived from them. It is noteworthy that the territory adjoining Mt. Svobodny, which lies on old Tertiary quartz sands, abounds in goiters resulting from a deficiency of iodine. The content of copper is higher in the granites than in the lacustrine-alluvial deposits; it is found in the smallest quantities, however, in the sand deposits.

The data in Table 2, which relate to Section 218 (located on the weathered crust of granite in the Kheykhe area of the Kheyluntsyan province) confirm the idea that the formation of eluvium and fine-textured soil on granites is

---

[1] The general conditions of nature and soil formation in the Amur River area are described in the article by V. A. Kovda, Sun Da-chen and Yu. A. Liverovskiy (6).

[2] The spectrum analyses were done by G. D. Belitsynaya and M. A. Vinnik, workers in the department; the polarographic analyses were done by D. S. Orlov, N. M. Grindel' and V. D. Vasil'yevskaya.

Table 1

Minor elements content in soil forming parent materials of Upper Amur River area, in percentages of the ignited weighed portions; Zn and Co as percentages of portions dried at 105° C

Rock	B	V	Cr	Mn	Co	Ni	Cu	Zn	Sr	Ba
Granite	$9,2 \cdot 10^{-4}$	$<1,0 \cdot 10^{-3}$	$3,5 \cdot 10^{-3}$	$1,7 \cdot 10^{-2}$	Не опр.	$<5,0 \cdot 10^{-4}$	$2,3 \cdot 10^{-3}$	Не опр.	$1,0 \cdot 10^{-2}$	$4,5 \cdot 10^{-2}$
Lacustrine alluvium (fine clay loam)	$3,5 \cdot 10^{-3}$	$6,0 \cdot 10^{-2}$	$3,0 \cdot 10^{-2}$	$9,0 \cdot 10^{-2}$	$6,9 \cdot 10^{-4}$	$3,0 \cdot 10^{-3}$	$1,6 \cdot 10^{-3}$	$5,7 \cdot 10^{-4}$	$5,2 \cdot 10^{-2}$	$6,0 \cdot 10^{-2}$
Sand with gravel	$1,0 \cdot 10^{-3}$	$2,0 \cdot 10^{-2}$	$1,4 \cdot 10^{-2}$	$1,7 \cdot 10^{-2}$	$2,0 \cdot 10^{-3}$	$<1,0 \cdot 10^{-3}$	$1,0 \cdot 10^{-3}$	$1,2 \cdot 10^{-3}$	$5,7 \cdot 10^{-2}$	$4,0 \cdot 10^{-2}$
Tertiary sandy alluvium	$9,0 \cdot 10^{-4}$	$1,0 \cdot 10^{-2}$	$7,9 \cdot 10^{-3}$	$2,2 \cdot 10^{-2}$	$1,2 \cdot 10^{-3}$	$1,2 \cdot 10^{-3}$	$1,2 \cdot 10^{-3}$	$1,0 \cdot 10^{-4}$	$7,5 \cdot 10^{-2}$	$5,4 \cdot 10^{-2}$
Stratified flood-plain deposits	$7,2 \cdot 10^{-3}$	$2,0 \cdot 10^{-2}$	$1,5 \cdot 10^{-2}$	$8,9 \cdot 10^{-2}$	$5,8 \cdot 10^{-4}$	$2,0 \cdot 10^{-3}$	$3,9 \cdot 10^{-3}$	$8,6 \cdot 10^{-3}$	$8,7 \cdot 10^{-2}$	$4,5 \cdot 10^{-2}$

Table 2

Minor elements in the profile of a brown forest soil developed on the weathered crust of a granite, in percentages of ignited weighed portions. Section 218.

Horizon	Depth, cm	B	V	Cr	Mn	Ni	Cu	Sr	Ba
A_1	0—6	$6,5 \cdot 10^{-3}$	$1,2 \cdot 10^{-2}$	$1,0 \cdot 10^{-2}$	$3,1 \cdot 10^{-1}$	$5,0 \cdot 10^{-4}$	$7,5 \cdot 10^{-3}$	$2,8 \cdot 10^{-2}$	$5,0 \cdot 10^{-2}$
A/B	12—22	$2,1 \cdot 10^{-3}$	$7,2 \cdot 10^{-3}$	$6,9 \cdot 10^{-3}$	$7,7 \cdot 10^{-2}$	$<5,0 \cdot 10^{-4}$	$5,9 \cdot 10^{-3}$	$4,5 \cdot 10^{-2}$	$3,6 \cdot 10^{-2}$
B	70—90	$1,1 \cdot 10^{-3}$	$2,4 \cdot 10^{-3}$	$6,4 \cdot 10^{-3}$	$4,7 \cdot 10^{-2}$	$<5,0 \cdot 10^{-4}$	$6,0 \cdot 10^{-3}$	$2,7 \cdot 10^{-2}$	$2,5 \cdot 10^{-2}$
C	125—135	$2,3 \cdot 10^{-3}$	$8,9 \cdot 10^{-3}$	$6,6 \cdot 10^{-3}$	$3,0 \cdot 10^{-2}$	$1,4 \cdot 10^{-3}$	$2,5 \cdot 10^{-2}$	$4,6 \cdot 10^{-2}$	$8,8 \cdot 10^{-2}$
D (granite)	>200	$9,2 \cdot 10^{-4}$	$<1,0 \cdot 10^{-3}$	$<3,5 \cdot 10^{-3}$	$1,7 \cdot 10^{-2}$	$<5,0 \cdot 10^{-4}$	$2,3 \cdot 10^{-3}$	$1,0 \cdot 10^{-2}$	$4,5 \cdot 10^{-2}$

Note: Comma represents decimal point; $9,2 \cdot 10^{-4}$ (and other similar figures) means 9.2×10^{-4}.

accompanied by a general increase in the content of boron, chromium, strontium, nickel, vanadium, copper and manganese. The copper, vanadium, nickel and strontium, however, are evidence of the formation of a very distinct illuvium in the horizons below the soil and of the removal of elements from the upper part of the soil profile. The greater the degree of formation of fine-textured soil material and of a soil horizon, the higher the content of boron, chromium and manganese in the soil horizons.

amounts depending on the humus content. When the soil contains an A_2 horizon (podzolized), there is a decrease in the content of certain minor elements. The non-humic horizons as a rule are less rich in minor elements (Fig. 1). For the sake of a clearer representation of the distribution of minor elements through the profiles of the main soil groups of the Amur area, and especially of their accumulation in the humus horizon, average indices have been computed for each layer from data on several

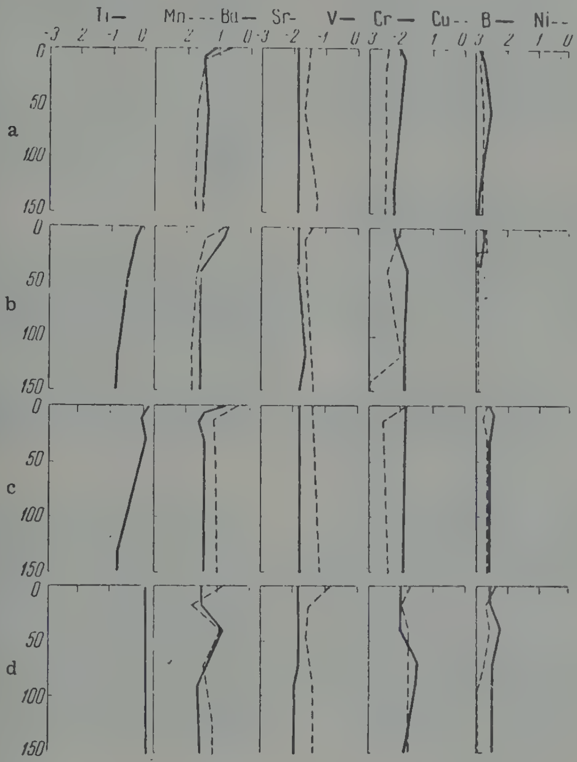


Fig. 1. - The content of minor elements in the profiles of the main soil groups of the Upper Amur River area (according to data from spectrum analysis, m x 10⁻ ⁿ%):

a - brown forest, section 213; b - brown-podzol, section 239; c - gley-podzol, section 241; d - thick meadow, section 208.

Materials for analysis were obtained from the four main soil groups of the Upper Amur River area: brown forest (Section 213), brown-podzolic (Section 239), gley podzolic (Section 241) and thick meadow (Section 208); these all show regular features in common.

In every case, the distribution curve of minor elements shows a clear overall increase in their content in the upper soil horizons. There is an especially large accumulation of minor elements in the humus horizon, their

soil sections. The results in the case of copper are shown in Table 3.

The available analytic data for soils of one group were treated as follows. The average content of one minor element or another was calculated for each soil section studied by computing the arithmetic mean of the results of analysis of the samples from the chief genetic horizons, taking their thicknesses into account. The average indices for the individual sections were then used to find the average figures for

Table 3

Copper distribution in genetic horizons of the main soil groups of Upper Amur River area, in percentages of the ignited weighed portions

Horizon	Brown forest	Brown-podzolic	Gley-podzolic	Thick meadow
A_1	$6,4 \cdot 10^{-3}$	$7,1 \cdot 10^{-3}$	$10,0 \cdot 10^{-3}$	$8,0 \cdot 10^{-3}$
A_2	$6,0 \cdot 10^{-3}$	$5,2 \cdot 10^{-3}$	$7,0 \cdot 10^{-3}$	—
B	$5,3 \cdot 10^{-3}$	$5,7 \cdot 10^{-3}$	$6,3 \cdot 10^{-3}$	$7,9 \cdot 10^{-3}$
C	$5,2 \cdot 10^{-3}$	$3,5 \cdot 10^{-3}$	$5,3 \cdot 10^{-3}$	$6,1 \cdot 10^{-3}$

Note: Comma represents decimal point; $6,4 \cdot 10^{-3}$ (and other similar figures) means 6.4×10^{-3}.

Table 4

Minor elements in the earth's crust, in chernozems and in main soil groups of Upper Amur River area, in percentages of the ignited weighed portions

Element	Average content in the earth's crust (according to Goldshmidt)	Chernozem[a]	Brown forest	Brown-podzolic	Gley-podzolic	Thick meadow	Floodplain meadow
Mn	$1,0 \cdot 10^{-1}$	$8,3 \cdot 10^{-2}$	$8,9 \cdot 10^{-2}$	$8,7 \cdot 10^{-2}$	$1,8 \cdot 10^{-1}$	$1,3 \cdot 10^{-1}$	$8,8 \cdot 10^{-1}$
Ba	$4,3 \cdot 10^{-2}$	$4,0 \cdot 10^{-2}$	$5,2 \cdot 10^{-2}$	$7,5 \cdot 10^{-2}$	$7,1 \cdot 10^{-2}$	$6,0 \cdot 10^{-2}$	$6,2 \cdot 10^{-2}$
Cr	$2,0 \cdot 10^{-2}$	$4,0 \cdot 10^{-2}$	$2,5 \cdot 10^{-2}$	$2,3 \cdot 10^{-2}$	$1,3 \cdot 10^{-2}$	$1,7 \cdot 10^{-2}$	$1,3 \cdot 10^{-2}$
Sr	$1,5 \cdot 10^{-2}$	$4,0 \cdot 10^{-2}$	$4,2 \cdot 10^{-2}$	$8,9 \cdot 10^{-2}$	$4,4 \cdot 10^{-2}$	$5,0 \cdot 10^{-2}$	$6,1 \cdot 10^{-2}$
V	$1,5 \cdot 10^{-2}$	$2,9 \cdot 10^{-2}$	$1,4 \cdot 10^{-2}$	$1,3 \cdot 10^{-2}$	$1,6 \cdot 10^{-2}$	$3,1 \cdot 10^{-2}$	$1,4 \cdot 10^{-2}$
Ni	$1,0 \cdot 10^{-3}$	$4,9 \cdot 10^{-3}$	$2,1 \cdot 10^{-3}$	$1,8 \cdot 10^{-3}$	$2,9 \cdot 10^{-3}$	$4,2 \cdot 10^{-3}$	$2,3 \cdot 10^{-3}$
Zn	$8,0 \cdot 10^{-3}$	$7,2 \cdot 10^{-3}$	$1,4 \cdot 10^{-3}$	$4,3 \cdot 10^{-3}$	$3,2 \cdot 10^{-3}$	$7,0 \cdot 10^{-3}$	$9,7 \cdot 10^{-3}$
Cu	$7,0 \cdot 10^{-3}$	$3,0 \cdot 10^{-3}$	$4,9 \cdot 10^{-3}$	$5,9 \cdot 10^{-3}$	$7,2 \cdot 10^{-3}$	$3,9 \cdot 10^{-3}$	$9,3 \cdot 10^{-3}$
Co	$4,0 \cdot 10^{-4}$	$6,1 \cdot 10^{-4}$	$1,7 \cdot 10^{-4}$	$7,2 \cdot 10^{-4}$	$6,5 \cdot 10^{-4}$	$5,7 \cdot 10^{-4}$	$5,6 \cdot 10^{-4}$
B	$1,0 \cdot 10^{-3}$	$1,2 \cdot 10^{-3}$	$2,9 \cdot 10^{-3}$	$2,4 \cdot 10^{-3}$	$4,6 \cdot 10^{-3}$	$5,5 \cdot 10^{-3}$	$8,4 \cdot 10^{-3}$

---

[a] The chernozem is taken as a standard.

Note: Comma represents decimal point; $1,0 \cdot 10^{-1}$ (and other similar figures) means 1.0×10^{-1}.

the profile of each soil group. The final step was to obtain the data given in Table 4, which shows the content of minor elements in the chief soil groups of the Upper Amur River area. An examination of the table will lead to the following conclusions:

Manganese is accumulated mostly in the floodplain soils, less in the meadow and gley-podzolic soils, and to a still lesser degree in the brown forest and brown-podzolic soils.

The amount of chromium in brown forest and brown-podzolic soils is twice as great as in the other soil groups.

Vanadium is accumulated in thick meadow and bog soils; in the remaining soils the vanadium content is on the same order.

Zinc is accumulated in meadow and gley-podzolic soils, with smaller amounts in brown-podzolic soils.

Copper accumulations are found in floodplain and gley-podzolic soils. In the remaining groups it occurs in somewhat smaller amounts.

The content of cobalt does not appear to difer in the various soil groups.

Barium is also contained in more or less he same amounts in all the soils.

Strontium is contained in noticeably higher mounts in the brown-podzolic soils and bog oils; in the other soils its content shows no ifferences.

Boron is accumulated in noticeable amounts n floodplain, gley-podzolic and bog soils.

Thus the general conclusion may be drawn hat such minor elements as manganese, copper, boron and zinc are accumulated in the loodplain soils of the Amur area. Chromium accumulates in the brown and brown-podzolic soils, which have relatively coarse textures and are subjected to more intensive aeration and oxidation.

A look at the data on the individual sections will reveal sharp fluctuations in the values for the brown soils; this is due to the great variety of soil forming parent material and degrees of erosion. The content of minor elements in the meadow soils, on the other hand, is very similar in all sections, because of the uniformity of the soil forming parent materials and the fullness and thickness of the humus horizon.

Like the major elements, the minor elements are capable of forming mobile compounds which, in migrating within the landscape, are removed from some types of weathered crust and accumulate in other types and soils. In particular, one may note the migration of manganese compounds from the soils and weathered crust of watersheds and their slopes and their later accumulation in floodplains. The removal of such elements as chromium, vanadium and copper may be observed from the profiles of brown-podzolic soils, which are usually located in the higher parts of the topography.

There is a quite clear accumulation of iodine in the humus and partly in the illuvial horizons (Table 5). A comparison of these data with those on the average contents of iodine (4, 8) (average in all soils, n x 10^{-4}%; in podzolic soils, 3 x 10^{-4}%; in chernozems, 1 x 10^{-3}%; in peaty-bog soils, 2 x 10^{-3}%) will show a certain deficiency of iodine in the soils of the Upper Amur River area (by 1/3 -- 1/2 -- 2/3 of an order of magnitude).

In order to detect the peculiarities in the minor element contents in the soils of the Amur region, these have been compared with the average contents of minor elements in the earth's crust (according to Goldshmidt) and the average contents of the minor elements in chernozems, which have been taken as a standard (Table 4).

Manganese. The average content of manganese in the earth's crust is 1 x 10^{-1}; chernozems contain manganese on the order of 10^{-2} (4). The meadow soils of the Amur area contain more manganese than do chernozems. In the brown and brown-podzolic soils manganese is present in the same amounts as in the chernozems.

Barium. The content of barium in the soils of the Amur area is of the same order as in the earth's crust and in chernozems: 10^{-2}. Within this order of magnitude, however, a clear increase is noted in the barium content of all the soils of the Amur region (by 1/3 of an order of magnitude).

Chromium. The chromium content in the Amur area soils is of the same order as in the earth's crust and chernozems: 10^{-2}. In the Amur meadow, bog and floodplain soils, however, the chromium content is smaller by a fraction of an order of magnitude.

Strontium. The strontium content is on the order of 10^{-2}. Within this order of magnitude, the strontium content in chernozems is expressed by the value 4 (4 x 10^{-2}). The Amur area soils differ sharply from the chernozems in their strontium content, and particularly from the average content in the earth's crust. Within the order of magnitude of 10^{-2}, the strontium content is expressed by the values 5 and 6 for meadow soils and 8-9 x 10^{-2} for brown-podzolic soils. Thus the richness of the Amur River area soils in strontium may be seen very clearly.

Vanadium. If the average content of vanadium in chernozems (on the order of 10^{-3}) is taken as the standard, the soils of the Amur area are richer in vanadium by a whole order of magnitude, so that the content is expressed by the figure n x 10^{-2}.

Nickel. In comparison to the chernozems of the Russian plain, the Amur area soils, except for thick meadow soils, are poorer in nickel, although the content remains within the same order (n x 10^{-3}). When compared to the earth's crust as a whole, the Amur area soils contain less nickel by a whole order of magnitude (1 x 10^{-2} in the earth's crust, 2-4 x 10^{-3} in the soils of the Amur River region).

Zinc. The thick meadow and floodplain meadow soils contain sufficient zinc; in the other soil groups there is some deficiency.

Copper. The soils of the Amur River area contain the same or greater amounts of copper, as compared to the chernozems, so that there is evidently no deficiency of this element (3 x 10^{-3} in chernozems, 4-9 x 10^{-3} in the Amur

Table 5

Iodine content in soils of Upper Amur River area, as percentages of weighed portions dried at 105° C

(Analyses by A. V. Glushchenko and Ye. P. Minenkova)

Soil	Section No.	Horizon	Depth, cm	Iodine content
Brown forest	213	A_1	0—7	$1{,}21 \cdot 10^{-4}$
		A_1/A_2	7—15	$1{,}04 \cdot 10^{-4}$
		B_2	55—65	$1{,}16 \cdot 10^{-4}$
		C	137—150	$3{,}50 \cdot 10^{-5}$
Brown-podzolic	258	A_2	0—6	$1 \cdot 46 \cdot 10^{-4}$
		A_2	10—20	$9{,}50 \cdot 10^{-5}$
		B_2	50—60	$6{,}32 \cdot 10^{-5}$
		C	120—130	$2{,}16 \cdot 10^{-5}$
Gley-podzolic	242	A_1	0—6	$1{,}39 \cdot 10^{-4}$
		A_2	10—20	$1{,}16 \cdot 10^{-4}$
		B	50—60	$1{,}59 \cdot 10^{-4}$
		C	120—130	$1{,}07 \cdot 10^{-4}$
Thick meadow	249	$A\partial$	0—5	$9{,}43 \cdot 10^{-5}$
		A_1	5—15	$8{,}34 \cdot 10^{-5}$
		III	40—50	$6{,}82 \cdot 10^{-5}$
		IV	80—90	$5{,}26 \cdot 10^{-5}$
Meadow floodplain	226	V	140—150	$3{,}97 \cdot 10^{-5}$
		A_1	0—10	$1{,}39 \cdot 10^{-4}$
		B	45--60	$1{,}69 \cdot 10^{-4}$
		C_2	125—140	$1{,}02 \cdot 10^{-4}$

Note: Comma represents decimal point; $1{,}21 \cdot 10^{-4}$ (and other similar figures) means 1.21×10^{-4}.

area soils).

Cobalt. The figures on the cobalt in the Amur River area soils are close to those for chernozems.

Boron. The meadow and floodplain-meadow soils of the Amur area are richer than chernozems in the total amounts of boron by half an order of magnitude.

This brief review shows that the soils of the Amur River region that have been investigated are distinguished not so much for their deficiency as for their greater content of minor elements. It is especially important to note that the Amur area soils contain greater quantities than the chernozems of such known toxic minor elements as strontium and barium. In comparison to the chernozems of the Russian plain, the soils of the Amur River region are also richer in vanadium and boron.

The ground-waters and river waters are more reliable indices of the migration of elements in soils and in the weathered crust of parent material. The Amur River in most cases has a lower concentration of minor elements than the ground-waters that have been reached by drill holes and wells. The ground-waters in the low alluvial terraces, on the other hand, show a clear accumulation of minor elements. Thus the concentrations of all the minor elements are greater by a half or a whole order in the soil-ground-waters of the meadow-terraces (Section 227) of the Amur than in the ground-waters of the higher topographic areas, which have been subjected to the process of eluviation (Table 6).

Table 7 shows the accumulation of zinc in the ground-waters of the floodplain terrace. Specimens were taken at the same time (August of 1957), in the vicinity of the village of Kumara in the Amur Oblast', from the Amur River, from old depression and from the soil sections in the floodplain.

Thus the opinion expressed by us that the floodplain and meadow terraces of the Amur and Zeya Rivers are areas of migration and partial accumulation of the products of erosion and soil formation (6) finds confirmation in all the minor elements. The ground-waters of the Tertiary sandy plain (Section 213, Table 6), on the other hand, contain much smaller total

Table 6

Data on the spectrum analysis of ground-water samples from Upper Amur River area, g/l

Section No.	Soils and geomorphologic positions of the sections	V	Cr	Mn	Ni	Cu	Sr
213	Brown forest soil in a Tertiary plain	$2,7\cdot10^{-7}$	$3,0\cdot10^{-7}$	Not det.	$2,7\cdot10^{-7}$	Not determined	
225	Brown, podzolized soil. Edge of a watershed area	$4,8\cdot10^{-5}$	$3,5\cdot10^{-5}$	$4,2\cdot10^{-5}$	$5,3\cdot10^{-6}$	Not det.	$4,8\cdot10^{-6}$
240	Slightly peaty, gley-slightly podzolic soil. Super-floodplain terrace II	$4,8\cdot10^{-5}$	$4,8\cdot10^{-5}$	$5,4\cdot10^{-5}$	$1,1\cdot10^{-5}$	$7,5\cdot10^{-5}$	$6,6\cdot10^{-5}$
242	Gley-slightly podzolic super-floodplain terrace II	$4,8\cdot10^{-5}$	$4,0\cdot10^{-5}$	$6,0\cdot10^{-5}$	$9,9\cdot10^{-6}$	$6,2\cdot10^{-5}$	$6,1\cdot10^{-5}$
236	Meadow-bog soil with floodplain conditions	$4,8\cdot10^{-5}$	$4,1\cdot10^{-5}$	$5,3\cdot10^{-5}$	$9,8\cdot10^{-6}$	$8,5\cdot10^{-5}$	$1,9\cdot10^{-5}$
227	Bog-meadow floodplain soil. High floodplain of the Amur River	$4,8\cdot10^{-5}$	$1,1\cdot10^{-4}$	$1,7\cdot10^{-4}$	$3,0\cdot10^{-4}$	$2,1\cdot10^{-4}$	$2,1\cdot10^{-4}$

Note: Comma represents decimal point; $2,7 \cdot 10^{-7}$ (and other similar figures) means 2.7×10^{-7}.

Table 7

Zinc accumulation in floodplain waters in Kumara village area, g/l

Amur River	Water from station on floodplain	Water from depth of 109 cm. Bog-meadow medium-thickness soil. Section 368	Water from depth of 192 cm. Meadow-forest soil. Section 372
$2,27\cdot10^{-6}$	$6,50\cdot10^{-6}$	$7,12\cdot10^{-6}$	$1,94\cdot10^{-5}$

Note: Comma represents decimal point; $2,27 \cdot 10^{-6}$ (and other similar figures) means 2.27×10^{-6}.

concentrations of all the minor elements (by one or two orders of magnitude).

Table 8 shows our data on the vegetation of the Amur River region. Boron, manganese and nickel are contained, in the following decreasing order, in: the roots of grasses, leaves of oaks, larch-tree needles, the mantle of grasses and ears of wheat. In the case of vanadium, chromium, copper, strontium and barium, the decreasing order of their content is as follows: roots, oak leaves, grassy mantle, larch needles and ears of wheat. The greatest accumulation of all the minor elements has been found in roots (the larch needles and the mantle of grass change places in the cases of some elements).

Comparison of these quantities with the average data obtained by other authors (2, 5) has revealed some decrease in the case of boron and nickel only, while the contents of

Table 8

Minor elements in certain parts of the vegetation of Upper Amur River area, in percentages of the air-dried weight

Elements	Roots of grasses	Leaves of Quercus mongolica	Needles of Larix dahurica	Grass cover	Ears of wheat	Average data from Soviet authors		
						Grass	Decid-uous	Conifer-ous
B	$9,25 \cdot 10^{-4}$	$1,51 \cdot 10^{-3}$	$1,17 \cdot 10^{-3}$	$7,97 \cdot 10^{-4}$	$1,84 \cdot 10^{-4}$	Average $n \cdot 10^{-3}$		
V	$1,09 \cdot 10^{-3}$	$4,69 \cdot 10^{-4}$	$6,54 \cdot 10^{-5}$	$1,85 \cdot 10^{-4}$	$6,37 \cdot 10^{-5}$	Average $n \cdot 10^{-4}$		
Cr	$6,08 \cdot 10^{-4}$	$3,99 \cdot 10^{-4}$	$1,93 \cdot 10^{-4}$	$3,69 \cdot 10^{-4}$	$3,18 \cdot 10^{-4}$	Not determined		
Mn	$9,02 \cdot 10^{-3}$	$4,83 \cdot 10^{-3}$	$4,41 \cdot 10^{-3}$	$7,57 \cdot 10^{-4}$	$6,18 \cdot 10^{-4}$	$1,05 \cdot 10^{-3}$		
Ni	$1,42 \cdot 10^{-4}$	$3,18 \cdot 10^{-5}$	$1,76 \cdot 10^{-5}$	$3,99 \cdot 10^{-5}$	$3,18 \cdot 10^{-5}$	$1,11 \cdot 10^{-4}$	$4,50 \cdot 10^{-4}$	$6,30 \cdot 10^{-4}$
Cu	$7,40 \cdot 10^{-4}$	$3,25 \cdot 10^{-4}$	$2,27 \cdot 10^{-4}$	$4,25 \cdot 10^{-4}$	$3,38 \cdot 10^{-4}$	$6,24 \cdot 10^{-4}$	$4,20 \cdot 10^{-5}$	$1,60 \cdot 10^{-4}$
Sr	$2,72 \cdot 10^{-2}$	$1,41 \cdot 10^{-2}$	$4,02 \cdot 10^{-3}$	$8,43 \cdot 10^{-3}$	$1,91 \cdot 10^{-4}$	Average $n \cdot 10^{-4}$		
Ba	$1,35 \cdot 10^{-2}$	$5,27 \cdot 10^{-3}$	$1,17 \cdot 10^{-3}$	$2,23 \cdot 10^{-3}$	$1,91 \cdot 10^{-3}$	Average $n \cdot 10^{-4}$		

Note: Comma represents decimal point; $9,25 \cdot 10^{-4}$ (and other similar figures) means 9.25×10^{-4}.

Table 9

Contents of minor elements, in descending orders

Items	Minor elements
Crust of the earth	Mn, Ba, Cr, Sr, V, Ni, Zn, Cu, Co, B
Chernozems	Mn, Ba-Cr-Sr, Zn, Ni, Cu, V, B, Co
Soils of Upper Amur River area	Mn, Ba, Sr, V, Cr, Cu, B, Zn, Ni, Co
Waters	Cu, V, Mn, Cr, Sr, Ni
Plants	Sr, Ba, Mn, B, V, Cu, Cr, Ni

manganese, vanadium and copper in the Amur River area's vegetation hover about the average quantities. The data on strontium and barium are of interest -- these exceed the existing average data by an entire order of magnitude (except for the ears of wheat).

It is far too early to derive any conclusions or generalizations from this material. In the Amur River region, however, the problem arises of the possible role of strontium and barium in the diseased and abnormally developed skeletons of living creatures.

In conclusion, Table 9 compares the descending orders of the contents of minor elements in the soils, waters and plants of the Amur region with those of the earth's crust and the chernozems.

The soils and waters of the Amur River area show greater contents of vanadium, and zinc and nickel take the places of other elements, in which there are some deficiencies.

There is clearly a relatively higher accumulation of copper in the waters and of strontium in the vegetation of the Amur River region.

CONCLUSIONS

1. Of the soil forming parent materials of the Upper Amur River area, the richest in minor elements are the lacustrine-alluvial and floodplain deposits and the poorest are the Tertiary quartz sands and granites.

2. In all the soil groups, there is a biogenic

accumulation of minor elements in the humus horizon and a certain decrease in the A_2 (podzolized) horizon.

3. Comparison of the contents of minor elements in various soil groups has shown that many minor elements are accumulated in the floodplain and meadow soils of terraces -- manganese, copper, boron and zinc. The same thing characterizes the ground-waters of the floodplains and lower terraces.

4. Data on the iodine content in certain soils indicate a definite deficiency of this element in the soils of the Upper Amur area.

5. The soils of the Amur region are richer, as compared to chernozems, in strontium, barium, vanadium and boron, and poorer in zinc and nickel.

6. Analysis of vegetation samples has revealed the following decreasing order in the contents of the minor elements: roots of grasses, oak leaves, larch needles, grass cover and ears of wheat.

In the region investigated, the barium and strontium contents are higher and the nickel and boron contents lower than the averages.

Received March 7, 1958

BIBLIOGRAPHY

1. ARINUSHKINA, YE. V. and T. P. BOLTENKO. 1952. Determination of the boron content in vineyard soils and in vines. Uch. zap. Mosk. gos. un-ta. Izd-vo Mosk. un-ta No. 141.

2. BOL'SHOVA, T. A. 1954. The effect of certain conditions on the content of minor elements in hay. Uch. zap. Vitebsk. vet. in-ta Vol. 13, pp. 92-98. Vitebsk.

3. VINOGRADOV, A. P. 1932. The geochemistry of living matter. Izd-vo Akad. Nauk SSSR.

4. VINOGRADOV, A. P. 1957. The geochemistry of rare and disseminated elements in soils. Izd-vo Akad. Nauk SSSR.

5. VINOGRADOV, A. P. 1952. The basic laws governing the distribution of minor elements between plants and the media in which they grow. Publications of the Conference on Minor Elements, 1950. Izd-vo Akad. Nauk SSSR.

6. KOVDA, V. A., YU. A. LIVEROVSKIY and SUN DA-CHEN. 1957. An outline of the soils of the Amur River region. Izv. Akad. Nauk SSSR Ser. Biol., No. 1.

7. 1957. The Inter-university Conference on the Minor Elements in the Soils of the USSR, March 16-26, 1957. Papers and Methods of Indication. Moscow.

8. SELIVANOV, L. S. 1939. The geochemistry and biogeochemistry of disseminated bromine. Trudy Biogeokhim. lab. Akad. Nauk SSSR, Izd-vo Akad. Nauk SSSR Vol. 5.

9. TROITSKIY, YE. P. and R. A. MEL'TSER. 1952. Determination of the Haloid content in soils. Uch. zap. Mosk. gos. un-ta, No. 141 Izd-vo Mosk. un-ta.

BIOPHYSICAL AND CHEMICAL ANALYSIS OF SOIL AGGREGATES

M. G. TYAGNY-RYADNO
Kuybyshev Agricultural Institute

V. R. Vil'yams (3) has made the well-founded assertion that soil fertility is determined by the presence of a stable, blocky granular structure. Along with Omelyanskiy (8), moreover, he has pointed out that anaerobic conditions of microbial existence are created within the soil aggregates, and aerobic conditions on their surfaces. No experimental proof was offered, however. We have therefore undertaken the task of studying the biophysical and chemical processes not only in average undifferentiated soil samples, but also within aggregates of various diameters.

Individual problems in the biophysical and chemical analysis of soil aggregates have been worked out. As early as 1927-1930, for example, Uspenskiy (18) was urging the necessity of studying the biochemical processes in the local nuclei of soil around the nidus of nitrificators and within the individual structural elements. In 1928-1931 Sokolov suggested studying microscale changes in the soil forming processes in aggregates of various diameters and in 1947 he presented a well-developed and well-founded microdynamic analysis of the distribution of nutrients in an average soil sample and in aggregates. We began our investigations in this area of study as early as 1933 at the Tashkent Rice Experimental Station, and continued them in 1938 at the All-Union Institute of Olive Culture in Krasnodar. The results of these investigations were first reported to the All-Union Conference on Agricultural Microbiology, in April 1948 (16). Antipov-Karatayev and his colleagues (1) have thoroughly studied the soil aggregates. Novogrudskiy (7) has studied the microflora on the surfaces of the soil structural elements, Kachinskiy (5) has investigated the differential porosity of soil aggregates, and Hagin (22) and Strickling (24) have determined the amounts of nitrates in different aggregates. Domsch (21) has studied the P_2O_5 and K_2O and Wichtmann (23) the physical properties of aggregates. Khan (19) has investigated the humus, nitrogen, exchangeable cations and the particle size of various aggregates. In 1957 Burov (2) studied the moisture properties in aggregates.

This article presents the results of investigations from 1955-1957 in the meadow and meadow-bog soils and solonchaks of the Kara-Kalpak Experimental Station of the Uzbek Academy of Sciences. They are located on the lower reaches of the Amu-Dar'ya River in the Kegeylin rayon of the Nukus Oblast', in the typical sierozems of the Ordzhonikidze rayon in the Tashkent Oblast', and in the ordinary chernozems of the Kinel' rayon in the Kuybyshev Oblast'. Both aggregates and average soil samples were analyzed; these were taken from the A horizon of virgin soil areas. The following method of biophysical and chemical analyses was used: aggregate analysis of the soils was determined by Savvinov's method (11); humus content by Tyurin's method (15); total nitrogen content by Kjeldahl's method; ammonia, nitrates and P_2O_5 colorimetrically; chloride ion and the solid residue by the volumetric method; and the pH, Eh and rH_2 electrometrically (9, 12).

The oxidation-reduction potential and the pH within the aggregates were determined by piercing the aggregates with a platinum needle electrode having a wire no longer than 3 mm. The point where the aggregate touched the glass tube of the electrode (in order to eliminate possible polarization on the wire at the base of the electrode) was coated with paraffin, as suggested by S. P. Serdobol'skiy. The aggregates were placed in a glass tube 5 mm in diameter and 3-4 cm high. The lower end of the tube was covered by gauze with a small end protruding. The aggregates of 3 mm diameter were placed in the tube one after the other; the aggregates smaller than 0.25 mm in diameter occupied several rows and were placed together more densely, so that they filled up all the interstices in the upper layer. The tube containing the aggregates was lowered into a test tube with such an amount of distilled water that the end was slightly moistened. When the top aggregate was moistened, the electrode (platinum needle) was pushed into the aggregate, and the Eh was determined. After the latter had been determined on the moistened aggregate, quinhydrone was poured on the tip of the blade and the pH was determined. These determinations were made on a P-4 potentiometer. Three tubes with aggregates and electrodes were placed together in the system shown in Figure 1, so as to obtain compensation in the circuit as rapidly as possible.

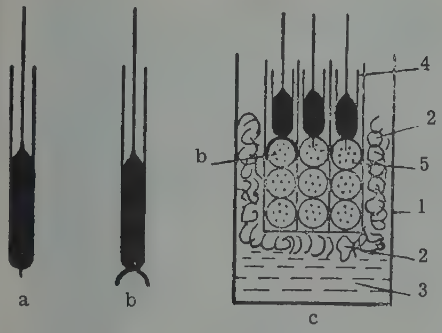


Fig. 1. - Measurement of the Eh and pH in soil aggregates:

a - needle electrode, b - horn electrode, c - electrodes in operation. 1 - container with water; 2 - gauze; 3 - water; 4 - glass tube containing aggregates; 5 - needle electrode, inserted into the aggregate; 6 - horn electrode, placed over the surface of the aggregate.

To eliminate polarization and to find the points of compensation more rapidly, the rheochord of the potentiometer was moved quickly to the right and to the left and then gradually brought together. In addition, a condenser with a capacity of $2\mu F$ was included in the circuit.

In determining the Eh on the surfaces of the aggregates, an electrode with two short platinum wires was used; this was called the horn electrode (Fig. 1b) and was seated over the aggregates in the same tubes. The pH on the surface of the aggregate was determined not by piercing it with the electrode, but by placing the horn electrode over the moistened aggregate.

The quantitative composition of the microflora was determined by breaking up the average soil sample or the aggregates. The amounts of aerobic microflora were counted in age soil sample or the aggregates. The amounts of aerobic microflora were counted in meat-peptone agar; the ammonificators in a peptone medium, the nitrificators in a Vinogradskiy medium, the denitrificators in a Gil'tay medium, um and the spore bacteria in meat-peptone agar by Mishustin's method. The total amounts of microflora in the aggregate were determined by breaking up the sample, except that instead of using an average soil sample for this analysis, aggregates of specific diameters obtained by fractioning the soil in sieves dried with alcohol were used. By the same method, average samples of aggregates ranging from 10 mm-<0.25 mm in diameter were taken from each fraction. In this article, the 10-5 mm diameter aggregates are called macroaggregates, the 3-1 mm diameter aggregates are called mesoaggregates, and those from 0.5-<0.25 mm in diameter are called microaggregates.

The microflora within the aggregates were analyzed as follows: aggregates in the amount of 1.0 g were poured into a sterile (Wasserman) test tube and poured over a thin layer of collodion. They were then poured quickly into a sterile, flat-bottomed flask with 100 ml of water. The flask was thoroughly agitated until the aggregates were fully broken up; after this dispersion the soil suspension was poured into Petri dishes with meat-peptone agar. The colonies that had developed and were counted in the Petri dishes were the microflora within the aggregates; the microflora on the surfaces of the aggregates was calculated by the difference between the total microflora and the microflora within the aggregates.

Treatment of all the data by the method of statistical variations has shown that they fall within the limits of accuracy of the analysis. The percentage of error was 2-5% in the analysis of the aggregates and 10-16% in the analysis of average soil samples.

EXPERIMENTAL SECTION

Structure and salt content of soils

Before going on to the biophysical and chemical analyses, it is important to establish the structural composition of the soils that were investigated. The dynamics of the soil structure were very variable, since the structure of the soil changed continuously during the year. The greatest percentage of macroaggregates, 47.6%, was found in the meadow-bog soil; the greatest percentage of mesoaggregates, 61.8%, was found in the ordinary chernozem; and the greatest percentage of microaggregates, 47.6-45.6%, was found in the solonchaks.

The highest salt content was in the solonchaks -- fluffy and crusty -- where the average concentration of Cl-ion was 0.5-0.86% in the aggregates and 1.6-1.86% in the solid residue. The meadow-bog and meadow soils contained less salts. The aggregates of various diameters had different amounts of salts: in the meadow soil, for instance, the 10 mm diameter aggregates contained 0.016% of Cl-ion, the <0.25 mm diameter aggregates 0.040> and the 3 mm diameter aggregates 0.012%. In the meadow-bog soil, on the other hand, the large 10 mm diameter aggregates contained a higher percentage of salts (0.047%) than the <0.25 mm diameter aggregates (0.009% of Ci-ion).

Actual reaction and oxidation-reduction potential of the aggregates. Two of the most important factors in the growth and development of bacteria in the soil are the magnitude of the oxidation-reduction potential and the actual reaction in the medium. These factors also govern the metabolic exchange of substances by the microorganisms and the higher plants. The interrelationship between these life processes and the oxidation-reduction conditions of the medium and the magnitude of its pH have been studied and convincingly proved in papers by Uspenskiy (17), Shaposhnikov (20), Nekrasov (6), Remezov (10), Rabotnova (9) and Serdobol'skiy (12). The oxidation-reduction properties of the aggregates in structured and pulverized soils were first studied by Serdobol'skiy (12). I assert that anaerobiosis in the aggregates is a characteristic only of structured soils.

My investigations have shown that the decrease in the magnitude of the oxidation-reduction potential within the aggregates is determined not only by the structure of the soil and the moisture in it, but mainly by the sizes of the aggregates and the period and stages of the soil forming process at which the aggregates were created. Table 1, in fact, shows that the aggregates in a soil of the steppe period have a higher oxidation-reduction potential than those in a soil in the desert period of soil formation. The lowest potential was found in the meadow-bog stage. In all four soils, however, the magnitude of the potential on the surfaces of the aggregates was greater than it was within them. Aerobic conditions were predominant in the aggregates of 3 mm diameter, and anaerobic conditions in those of 0.25 mm diameter. Differences in the oxidation-reduction potential have also been observed in analyzing the suspensions of average soil samples and of aggregates. Whereas in ordinary chernozems, for example, the Eh on the surfaces of 3 mm diameter aggregates was 540 mv and the rH_2 was 31.8; within these aggregates the Eh was 490 mv and the rH_2 was 30.3. The potential in the aggregate suspension was 382 mv and the rH_2 was 26.9; in the average soil sample suspension these were 406 mv and 28.1, respectively.

On the surfaces of the 3 mm diameter aggregates of the typical sierozem, the Eh was 402 mv; within the aggregates this diminished to 336 mv. In the aggregate suspension the Eh was 358 mv and in the average soil sample suspension 365 mv. The corresponding magnitudes of the rH_2 were: 27.4, 25.8, 26.3 and 27.1.

A similar pattern was found in the case of the meadow and meadow-bog sierozem, except that here the values of Eh and rH_2 were considerably lower (Table 1).

The changes in the pH were less obvious. The pH was practically the same in the ordinary chernozem on the surfaces and within the aggregates and also in the soil suspension, but the 0.25 mm diameter aggregates was more alkaline than the 3 mm diameter aggregates (by 0.2-0.3 pH). The same pattern appeared in the other soil groups. A noticeable difference in the magnitude of the pH appeared in comparing the individual soil groups with each other. There is a distinct difference between the meadow-bog sierozems, in which the pH in the aggregates reaches the magnitude of 6.2, and other soils, in which it fluctuates about a neutral or weakly alkaline reaction (6.9-7.3). The pH in the average soil sample suspension in the case of meadow and typical sierozems is as high as 7.5-7.6, whereas in the aggregates it is 7.2.

Microflora in the aggregates. The investigation has shown that the quantity of aerobic bacteria in the average soil samples is somewhat different from that in the aggregates (Table 2). In the meadow soil, for example, the aerobic bacteria average 2819 thousand per 1 g of macroaggregates, 2189 thousand per 1 g of mesoaggregates, 697 thousand per 1 g of microaggregates and 1024 thousand per 1 g of the average soil sample. The differences are even greater between the aggregates of different diameters. The data show that the mesoaggregates, especially those of 3 mm in diameter, contain more favorable conditions for the growth of aerobic bacteria than the microaggregates. The same thing has been found in the case of the fluffy and crusty solonchaks. In the fluffy solonchaks the greatest quantity of aerobic bacteria was found in the mesoaggregates (32.8 thousand), the next greatest in the macroaggregates (17.3 thousand) and the smallest quantity in the microaggregates (12.2 thousand). This distribution of the bacteria in the aggregates is probably due to the higher oxidation-reduction potential in the meso- and macroaggregates (see Table 1).

In the ordinary chernozem, the maximum number of aerobic bacteria was observed in the mesoaggregates (25,500 thousand), the minimum in the macroaggregates (11,000 thousand), and 15,000 thousand were found in the average soil sample. The largest quantity of aerobic bacteria in this soil type was found in the smallest fraction -- <0.25 mm in diameter

Table 1

Oxidation-reduction potential and pH in aggregates and in an average soil sample.
A horizon — virgin soil

Item	Soil	pH: Soil suspension	pH: Within aggregate	pH: On surface of aggregate	Eh, mv: In soil suspension	Eh, mv: Within aggregate	Eh, mv: On surface of aggregate	rH_2: In soil suspension	rH_2: Within aggregate	rH_2: On surface of aggregate
Average soil sample	Ordinary Chernozem	7.3	—	—	406	—	—	28.1	—	—
3 mm diameter		7.1	7.0	6.9	382	490	540	26.9	30.3	31.8
aggregate "0.25"		7.0	7.2	7.2	359	365	384	26.0	26.3	27.0
Average soil sample	Typical Sierozem	7.5	—	—	365	—	—	27.1	—	—
3 mm diameter		7.2	7.3	7.0	358	336	402	26.3	25.8	27.4
aggregate "0.25"		7.6	7.4	7.3	273	254	320	24.3	23.5	25.3
Average soil sample	Meadow Soil	7.6	—	—	320	—	—	25.8	—	—
3 mm diameter		7.1	7.0	6.9	338	312	360	25.3	24.4	25.8
aggregate "0.25"		7.3	7.2	7.1	257	224	286	23.2	21.7	23.7
Average soil sample	Meadow-bog Soil	6.8	—	—	283	—	—	23.0	—	—
3 mm diameter		6.3	6.5	6.2	268	247	281	21.6	21.2	21.8
aggregate "0.25"		6.4	6.6	6.4	234	209	252	20.6	20.2	21.2

Table 2

Total amounts of aerobic bacteria, in thousands per 1/g, in aggregates and in an average soil sample. A horizon —
Virgin soil

Samples		Meadow soil	Solonchak: Crust	Solonchak: Fluffy	Typical sierozem	Ordinary chernozem
Average		1024	4,3	12,1	25490	15000
Aggregates of 10 mm diameter	macro	2619	5,9	13,8	43700	—
" " 7 " "		2890	6,4	15,9	54950	8500
" " 5 " "		2948	6,8	22,1	38400	13500
Average for macroaggregates		2819	6,4	17,3	45680	11000
Aggregates of 3 mm diameter	meso	2977	7,9	54,6	42500	29500
" " 2 " "		2116	6,3	25,3	54000	—
" " 1 " "		1474	5,4	18,6	46320	22500
Average for mesoaggregates		2189	6,5	32,8	47606	25500
Aggregates of 0. 50 mm diameter	micro	979	7,1	17,9	24140	19000
" " 0. 25 " "		612	6,2	10,3	57800	13500
" < 0. 25 " "		502	3,1	8,4	75680	35000
Average for microaggregates		697	5,5	12,2	52540	22500

Note: Comma represents decimal point.

(35,000 thousand); the reverse pattern appeared in the typical sierozem, where the greatest number of aerobic bacteria appeared in the microaggregates (52,540 thousand) and the smallest number in the mesoaggregates (47,606 thousand) and in the macroaggregates (45,680 thousand). This is evidently to be explained by the fact that in the sierozem microaggregates, more favorable conditions are created for the decomposition of the organic residues in the soil by the ammonifying bacteria (see Table 5); this has already been established by Kononova's investigations (5).

Recalculation of the total quantities of aerobic bacteria by the actual content of the aggregates in one soil or another changes the data and produces greater accuracy, since in the chernozem and typical sierozem the actual maximum of aerobic bacteria is not in the pulverulent fraction (<0.25 mm in diameter), as would appear from Table 2, but in the mesoaggregates of 3 mm diameter (Table 3).

Determination of the microbe population in the average soil samples may thus introduce important corrections into the bacteriological analysis of the aggregates, which has established that the differences in the growth of the aerobic bacteria are related to the sizes of the aggregates and their content.

The investigations have shown that in some soil groups the aggregates of 3 mm diameter have three times as many bacteria on their surfaces as within. In the meadow soil, for example, there are 734 thousand bacteria within 1 g of aggregates and 2243 thousand on their surfaces; in the typical sierozem the corresponding quantities are 9,600 and 32,900 thousand. In the other soils (ordinary chernozem, meadow-bog and crusty and fluffy solonchaks) there are two or three times as many bacteria within the aggregates as on their surfaces (Table 4).

The photograph (Fig. 2) shows that there are more bacteria in the 3 mm diameter aggregates of the typical sierozem and ordinary chernozem than in the 0.25 mm diameter aggregates and the average soil samples. Besides the differences in quantity, qualitative differences in the species of bacteria contained in aggregates of different diameters have been found.

Figure 3 shows the growth of the microflora of the aggregates in meat-peptone agar after treatment with collodion. The whole aggregates in the lower parts of the Petri dishes show no growth in the microflora on their surfaces even after three twenty-four-hour periods. In the upper parts of the dishes, which contain the broken up aggregates, one may observe the extensive growth of the microflora within the aggregates.

The total quantities of the individual physiological groups of microorganisms in the aggregates also differ in relation to the aggregate diameters. The mesoaggregates of the meadow soil contain the largest numbers of ammonifiers, denitrifiers and spore formers, whereas the nitrifiers, nitrogen bacteria and cellulose bacteria are concentrated in the microaggregates. In the crusty solonchaks, on the other hand, more nitrogen bacteria, nitrifiers and cellulose bacteria have been noted in the mesoaggregates and more ammonifiers, denitrifiers and spore formers in the microaggregates. In the fluffy solonchak and the sierozem, the greatest content of all the physiological groups was found in the microaggregates, and that in the mesoaggregates was considerably smaller. In the ordinary chernozem, the mesoaggregates contain most of the ammonifiers, nitrogen bacteria, nitrifiers and cellulose bacteria, whereas the denitrifiers and spore formers are contained mostly in the microaggregates (Table 5).

The microflora in the aggregates change in relation to the soil group and the time of year -- in other words, the relation to the ecology. In the meadow soil, for instance, the ammonifiers in autumn multiply best in the microaggregates (31.6 thousand); the nitrifiers appear in large quantities in the autumn, spring and the first half of the summer mainly in the mesoaggregates (64.1 thousand) and then decline in number (6.9 thousand); the denitrifiers multiply well throughout the whole year, but better in autumn than in summer, and in the microaggregates (49.6 thousand) more than in the mesoaggregates (28.0 thousand). In the meadow-bog soil all three groups multiply with equal rapidity in the second half of the summer and for the most part in the mesoaggregates (19.2, 14.5 and 25.6 thousands respectively). In the crusty solonchak the ammonifiers (18.2 thousand) and the nitrifiers (14.3 thousand) predominate in autumn and summer in the mesoaggregates, and the denitrifiers during the same period in the microaggregates (24.3 and 15.6 thousand). In the fluffy solonchak the ammonifiers multiply well in summer in the microaggregates (15.6 thousand), the nitrifiers at the beginning of June in the mesoaggregates (12.0 thousand), and the denitrifiers during this same time in both the meso- and the microaggregates (14.5 and 13.1 thousands).

Accumulation of nutrients and humus in the aggregates. The aggregates reveal differences not only in the growth of microorganisms, but also in the mineralization of the organic residues in the soil and in the formation of humus. In addition to this, different aggregates contain different accumulations of the available nutrients in the soil. In the soils investigated

Table 3

Total amounts of aerobic bacteria, millions per g of soil
A horizon — virgin soil

Diameter of aggregates, mm	Meadow soil		Crusty solonchak		Fluffy solonchak		Typical sierozem		Ordinary chernozem	
	% of aggregates in soil	Total bacteria in aggregates	% of aggregates in soil	Total bacteria in aggregates	% of aggregates in soil	Total bacteria in aggregates	% of aggregates in soil	Total bacteria in aggregates	% of aggregates in soil	Total bacteria in aggregates
10	9.4	24.6	8.0	0.047	9.4	0.130	6.0	262.2	5.0	161.0
7	11.0	31.8	5.8	0.037	5.4	0.086	9.9	543.5	7.1	60.4
5	12.4	36.6	7.2	0.049	6.8	0.150	14.1	541.4	12.5	168.8
3	13.2	39.3	11.4	0.090	11.0	0.601	25.0	1062.0	32.6	961.7
2	11.3	24.0	9.6	0.061	9.3	0.235	12.5	675.0	16.8	300.0
1	12.7	18.7	18.8	0.102	16.0	0.298	9.1	421.3	12.4	279.0
0.5	5.3	5.2	9.0	0.064	8.2	0.147	4.6	111.0	6.9	131.0
0.25	5.1	3.1	16.6	0.103	12.0	0.124	7.9	456.6	5.4	72.9
<0.25	19.6	9.8	13.6	0.042	21.9	0.184	10.9	825.1	1.3	45.5
Average in aggregates per 1 g of soil	—	1.92	—	0.0059	—	0.0195	—	49.0	—	21.8

Table 4

Microflora in aggregates of 3-mm diameter, thousands per 1 g of soil. A horizon — virgin soil

Soil	Microflora		
	Total in aggregates	Within and on surface of aggregates	
Meadow	2977	734	2243
Meadow-bog	3703	2956	747
Crusty solonchak	8.7	7.5	1.2
Fluffy solonchak	54.6	34.8	19.8
Typical sierozem	42500	9600	32900
Ordinary chernozems	29500	18900	10600

by us, for instance, ammonia concentrates mainly in the microaggregates, where the ammonifiers multiply well, the rH_2 is low and the pH is high (Table 6).

The nitrates tend to concentrate primarily in the mesoaggregates, where the oxidation-reduction potential is higher, the reaction in the medium is close to neutral and the nitrifiers multiply better. Available phosphoric acid accumulates in the microaggregates. The formation of P_2O_5 is related directly to the growth of the azotobacter cellulose bacteria, ammonifiers and to the colloidal composition of the soil. The greatest contents of the various nutrient substances in the chernozem are as follows: 29.3 mg of NH_3, 34.5 mg of NO_3, and 20.5 mg of P_2O_5 per 1 kg of aggregates. The greatest percentages of humus and nitrogen in the soil were found in the ordinary chernozem mesoaggregates (6.7% humus and 0.32% nitrogen). In the meadow-bog soil the content of humus in the mesoaggregates is 3.5% and that of nitrogen is 0.24%. In the typical sierozem the

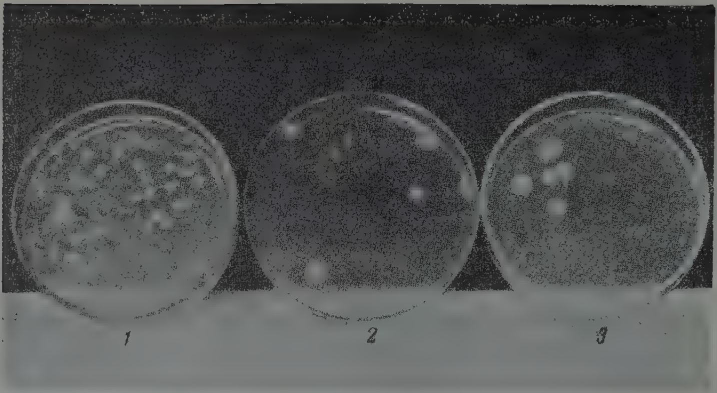


Fig. 2. - Microflora in ordinary chernozem aggregates

1 - aggregates of 3 cm diameter; 2 - aggregates of 0.25 mm diameter; 3 - average sample of soil.

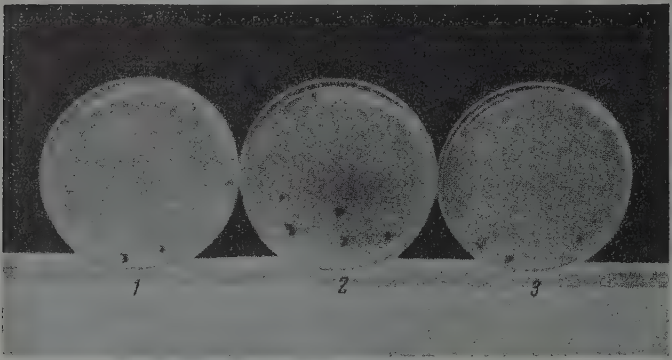


Fig. 3. - Growth of microflora on the surfaces and in the interiors of soil aggregates

1 - chestnut soil; 2 - ordinary chernozem; 3 - solodi.

respective amounts were 2.9% and 0.18%, and in the meadow soil 1.9% and 0.12% (Table 7).

Thus there is an intensive accumulation of humus and nitrogen in those aggregates in which the conditions for the growth of microflora, through the formation of humus, are the most favorable -- that is, in the meadow-bog soil and in the ordinary chernozem.

CONCLUSIONS

1. Correct estimation of soil fertility requires biophysical and chemical analysis not only of average soil samples, but also of soil aggregates of various diameters.

2. The pH, Eh and rH_2 within the aggregates differ sharply from those of the usual soil mixtures, which often have more reducing and alkaline properties. The mesoaggregates have a higher oxidation-reduction potential and a more neutral reaction in the medium than do the microaggregates, and the potential within all the aggregates is higher than on their surfaces.

3. The oxidation-reduction potential and the pH of the aggregates are determined by the periods and stages of the soil forming process, by the aggregate diameters and by their biophysical and chemical properties during the course of the annual cycle.

4. The total quantity of aerobic bacteria in

Table 5

Total amounts of microflora in aggregates, thousands per 1 g of aggregates in soil. A horizon — virgin soil

Soil	Aggregates	Ammonifiers	Nitrogen bacteria	Nitrifiers	Denitrifiers	Aerobic cellulose bacteria	Spore-forming bacteria
Meadow	Meso	2,4	3,5	6,9	18,3	4,7	5,7
	Micro	1,0	5,9	8,1	12,5	7,8	4,2
Crusty solonchak	Meso	2,3	0,4	6,0	11,8	1,4	3,6
	Micro	5,7	0,1	1,5	15,6	0,8	4,8
Fluffy solonchak	Meso	11,4	0,3	1,6	8,4	3,4	1,5
	Micro	15,6	0,5	3,2	9,7	5,5	2,6
Typical sierozem	Meso	38,0	64,7	15,6	9,3	19,1	11,5
	Micro	54,6	135,8	27,8	16,7	26,4	15,6
Ordinary chernozem	Meso	78,5	7,8	59,9	11,2	31,9	13,8
	Micro	45,4	4,5	42,1	30,8	18,7	16,9

Note: Comma represents decimal point.

Table 6

Content of available nutrients in aggregates, mg/kg of soil. A horizon — virgin soil

Aggregates	Meadow			Meadow-bog			Typical sierozem			Ordinary chernozem		
	NH_3	NO_3	P_2O_5	NH_3	NO_3	P_2O_5	NH_3	NO_3	P_2O_5	NH_3	NO_3	P_2O_5
Macro	2,8	1 2	17,0	4,3	0,6	18,6	9,2	5,2	20,8	21,6	10,7	12,9
Meso	3,5	4,7	12,8	3,7	1,4	18.3	12,6	21,3	35,9	23,4	34,5	15,4
Micro	6,9	2,3	10,5	5,8	0,5	26,9	18,9	3,4	54,7	29,3	26,1	20,5

Note: Comma represents decimal point.

Table 7

Content of humus and of total nitrogen in soil aggregates, percent. A horizon — virgin soil

Aggregates	Meadow		Meadow-bog		Typical sierozem		Ordinary chernozem	
	Humus	Nitrogen	Humus	Nitrogen	Humus	Nitrogen	Humus	Nitrogen
Macro	1,6	0,09	3,2	0,15	2,3	0,14	5,4	0,28
Meso	1,9	0,12	3,5	0,24	2,9	0,18	6,7	0,32
Micro	1,5	0,06	2,8	0,10	2,6	0,09	5,2	0,20

Note: Comma represents decimal point.

the aggregates differs according to their diameters. In some soils these bacteria are predominantly in the macroaggregates, and in others in the mesoaggregates. Bacteriological analysis of the aggregates supplements the usual analysis of average soil samples and makes the results more accurate. Both the aggregate diameters and their actual content in the soil are important in this regard.

5. In some soils there are more bacteria on the surfaces of the aggregates than within them (meadow soil, sierozem); in others there are two or three times as many microbes within the aggregates as on their surfaces (ordinary chernozem, meadow-bog soil, crusty and fluffy solonchaks).

6. The nutrients for higher plants accumulate differently in different aggregate diameters. In the majority of the soils investigated, ammonia and P_2O_5 are concentrated mainly in the microaggregates, and nitrates in the mesoaggregates. The greatest contents of humus and nitrogen in all the soil groups are found in the mesoaggregates, the smallest in the microaggregates and the medium-quantity accumulations in the macroaggregates. One must therefore study not only average samples of the soil, but also the aggregates composing it.

Received February 20, 1957

BIBLIOGRAPHY

1. ANTIPOV KARATAYEV, I. N., V. V. KELLERMAN and D. V. KHAN. 1948. Soil aggregates and the methods of investigating them. Published by Academy of Sciences, SSSR Moscow-Leningrad.

2. BUROV, D. L. 1957. Evaporation of water from the soil and the means of controlling it under the conditions of the Transvolga area. Izv. Kuybyshevsk. CKhI, 12:3-17.

3. VIL'YAMS, V. R. 1949. Soil Science. Agriculture and the foundations of soil science. Sel'khozgiz, Moscow.

4. KONONOVA, M. M. 1926. The microbiology of the soils in certain regions of Central Asia. Trudy Akkabakskoy op. orosit, St., Vol. 1, Tashkent.

5. KACHINSKIY, N. A. 1947. On the structure, certain moisture properties and differences in the porosity of the soil. Pochvovedeniye No. 6.

6. NEKRASOV, N. I. 1927. The physicochemical principles of determining the oxidation-reduction potential and its importance in biology. Usp. eksped. biol., No. 3-4.

7. NOVOGRUDSKIY, D. M. 1947. Effect of soil particle diameters on the distribution of microorganisms in the soil. Mikrobiologiya, 14:2, Moscow.

8. OMELYANSKIY, V. L. 1923. The fixing of atmospheric nitrogen by bacteria in the soil. Petrograd.

9. RABOTNOVA, I. L. 1957. The physicochemical conditions (pH and rH_2) as factors in the life activity of microorganisms. Published by Academy of Sciences, SSSR.

10. REMEZOV, N. P. 1929. Toward an understanding of the oxidizing and reducing processes in podzolic soils. Biol. pochvoveda, No. 4-6.

11. SAVVINOV, N. I. 1931. The soil structure in virgin soils, fallow soils and old cultivated areas. Sel'khozgiz.

12. SERDOBOL'SKIY, I. P. 1954. The methods of determining the pH and the oxidation-reduction potential in agrochemical investigations. Agrochemical methods in soil investigations. Published by Academy of Sciences, SSSR.

13. SERDOBOL'SKIY, I. P. 1958. Changes in the oxidizing and reducing conditions in the chernozem soils of the Kamennaya steppe. Problems of grass-crop rotation in agriculture. Vol. 2, pp. 438-437. Published by Academy of Sciences, SSSR.

14. SOKOLOV, A. V. 1947. Plant yields and the distribution of nutrients in the soil. 329 pp. Published by Academy of Sciences, SSSR.

15. TYURIN, I. V. 1937. Organic matter in the soil. Sel'khozgiz.

16. TYAGNY-RYADNO, M. G. 1957. A stenographic record of the speeches at the All-Union Conference on Agricultural Microbiology, from Ye. N. Mishustin's report. April 1948. A report to the Society of Soil Scientists of the Kuybyshev Oblast'. Pochvovedeniye No. 8.

17. USPENSKIY, YE. YE. 1936. The energy of life processes. In honor of K. A. Timiryazev. Sb. dokl. i materialov ses. Biol. in-ta im. K. A. Timiryazeva, GIZ, Moscow-Leningrad.

18. USPENSKIY, YE. YE. 1930. Trudy NIU. Sb. Mikrobiol. rabot, Vol. 1.

19. KHAN, D. V. 1957. The effects of mold substances, the mineral composition and the content of exchangeable cations on the formation of water-stable aggregates in chernozem soils. Pochvovedeniye No. 4.

20. SHAPOSHNIKOV, V. N. 1944. The significance of physiological criteria in the systematic classification of microorganisms. II. The genetic connection between energy-consuming processes. Mikrobiologiya, 13:1.

21. DOMSCH, M. 1955. Beriehungen zwischen Bodenstruktur and Naehrstoff analyse B. landw. Versuchs -- Untersuchungwesen, 46. (In German).

22. HAGIN, J. 1955. Rates of Nitrification in natural and "condition" formed soil aggregates of various sizes. Bull. Ress. council Israel, B. 5, No. 1, 98-104.

23. WICHTMANN. 1955. Untersuchungen zur Frage der Agregatbindekraefte in lufttrockenen Boden Kruemeln. Z. Pl. Dung. Bodenkunde, 71, 3, 232. (In German).

24. STRICKLING, E. 1955. Relationship of porosity to water stability in Beltsville soil aggregates. Soil Science, 80, No. 6, 449-457.

REVIEWS

SOIL COLLOIDS. POPULAR SCIENTIFIC SERIES OF THE PRESS OF THE ACADEMY OF SCIENCES, USSR. 1957

SOIL COLLOIDS. POPULAR SCIENTIFIC SERIES OF THE PRESS OF
THE ACADEMY OF SCIENCES, USSR. 1957.

N. I. GORBUNOV

This book by N. I. Gorbunov deserves special attention, since the author has intelligibly and at the same time thoroughly explained the study of soil colloids -- this fundamental and characteristic soil "plasma" which to a considerable degree determines all the specific properties of the soil and the processes that occur within it. The book examines in detail all the aspects of the composition of the soil colloids, their formation and changes in relation to the internal structure of the colloids and to the external conditions prevailing in the medium.

The first chapter is devoted to the all-important question of soil chemistry -- specifically its adsorption capacity, and in particular the ionic exchange of mineral and organic soil colloids. The author has given a fairly clear explanation of the structure of the micelle, including its double electric layer and its layer of ions determining the potential. It should be strongly emphasized, however, that the micelle as a whole is not a geometrically regular circle, as would appear from pages 11, 15, 16 and 17. The text contains a description of the electrokinetic properties of colloids, their chemical and mineral compositions, and the physicochemical properties of rocks and minerals as sources of the mineral colloids in the soil. The types of adsorption capacities of the soil, as well as the mechanism of cation exchange and the composition of the exchangeable cations, are set forth in some detail. The author has unfortunately not devoted sufficient attention to the problem of the intramicellar equilibrium, which is of great theoretical and no less practical importance.

The second chapter examines the solutions and the air in the soil. Here the author discusses the laws governing the exchange of cations, the energy with which the cations enter the adsorption complex, the equilibrium between the solid phase and the soil solution, and also the special role played by hydrogen ions in all the chemical processes within the soil, which determine the acidity of the medium. Particular attention is given to the changing acidity and the possible role played by aluminum ions in this process.

In connection with the soil acidity as related to the mineral and organic colloids, the author also examines the buffering properties of the soil and the soil solution, which are of essential practical importance in introducing acid fertilizers into the soil and in liming acid soils.

The third chapter describes some physical properties of soils and the extent to which they depend on the quantity and composition of the soil colloids: the swelling, stickiness and compaction of soil and their structure and microstructure. Certain methods of determining the physical properties of soils are also explained here.

In the fourth chapter special methods of studying soil colloids are set forth which the author has developed and applied with considerable success: the separation of colloids and clay from the soil, the use of X ray methods, thermal analysis, the application of the electron microscope, the use of radioactive atoms, chromatographic adsorption analysis and the identification of clay minerals by means of dyes.

As seen from the book's contents, all the basic physical, chemical and biological processes that take place within the soil are determined by the content of colloids, their quantity, composition and condition. For this reason N. I. Gorbunov's book is generally a valuable contribution.

Only a few of the book's faults will be noted here.

Colloids play a great role in the dynamics of the gaseous part of the soil. The author, however, has not devoted enough space to this topic, which is of essential importance both in agricultural engineering and in the theory of sorption. Nothing is said, for example, about the different gas capacities of soils in relation to the nature of their colloids, the substitution of some gases by others (exchange of gases), or the possible activation of simple gases, such as molecular oxygen, which has a decisive effect on the dynamics of all biochemical processes in the soil.

There are some unfortunate expressions: for example, "positively charged cations" (p. 88), "carbon particles" referring to the dispersed phase of smoke (p. 35), and "the degree of un-dissociation of the cations" (p. 88). It is hard to understand the expression "... weak van der Waals forces -- that is, forces which arise as a result of the displacement of the charges from the center of the molecules in the surface layer of the colloids" (p. 88, line 23 from the top).

Nevertheless these and other errors, unintelligible phrases, etc. in no way detract from the importance of this excellent and useful book.

As regards the present-day concepts of the structure and dynamics of soil colloids and the methods of investigating them, the author has set forth in concise form everything the nonspecialist needs to know in order to form a clear conception of the processes in the soil and the possibility of altering them in the desired direction in accordance with the goals of the national economy.

Reviewed by Ye. P. Troitskiy

SOIL COLLOIDS AND THE ABSORPTIVE CAPACITIES OF SOILS. STATE PRESS OF AGRICULTURAL LITERATURE. 1957

PROFESSOR N. P. REMEZOV

In a thorough study of the agricultural properties of soils and their fertility it is extremely important to know the content and the composition of the adsorption complex in the soil and the exchangeable ions associated with it -- i. e., the soil's adsorption capacity. The founder of the study of the adsorption capacity of soils in the USSR is Academician K. K. Gedroits, who in the last two or three decades of his life produced a number of works on this question.

The book by N. P. Remezov, published on the twenty-fifth anniversary of the death of K. K. Gedroits (1872-1932), is a monograph that will aquaint workers in the field of agriculture with the present state of the study of the adsorption capacity of soils. It is intended for workers in scientific research institutes, agrochemists, soil scientists, foresters, the faculties of universities and technical colleges, degree candidates and, in part, for students in advanced courses.

This book examines the role of soil colloids and exchangeable cations in producing the structure of the soil and their effect on the physical properties of soils. It also presents materials on the exchangeable cations available for agricultural crops and on regulating their composition in order to increase soil fertility.

It must be said that Remezov is well acquainted with the literature on this problem. In composing his book the author has therefore succeeded in making full use of the work of the greatest and best-known authorities (especially K. K. Gedroits) on the problems with which he is concerned. The book is written in fairly simple language; certain sections, however, will present difficulties to the reader.

In the chapter on the history of the adsorption capacity of soils, the author does not confine himself to citing similar works on this subject (by W. Knop, H. Hager, A. Gehring, I. N. Antipov-Karatayev, etc.), some of which are beyond the ordinary reader or are difficult to locate. He begins his history of the topic with Aristotle, Lucretius and Valerius, continues with the information obtained by I. Way, ver Bemmelen, P. A. Kostychev and others, and includes works by present-day authors (G. Wiegner, S. Mattson, K. K. Gedroits, etc.) in his chapter. There is a review of the various views on the factors that determine the adsorption capacity of soils (double aluminosilicates, zeolites, and the zeolite and humate portion of the soil; the significance of the particle surfaces -- their particle and ultra-particle size analyses; the relationship between the composition of the soil solution and the adsorptive capacity of soils). It is shown that individual investigations have clarified the essential features of the phenomenon of the soil's adsorption of cations and anions as functions of their valences, their atomic weights and the magnitudes of their atomic radius.

K. K. Gedroits' work is of course given a prominent place. It is well known that he conducted a series of laborious and carefully thought out experiments in studying the exchange reaction between the soil and the solution. As a result of these experiments, he published a theoretical monograph (which has gone through several editions) in 1922 setting forth the results of his investigations in the field of the adsorption capacity of soils and linking them closely with practical problems in agronomy. Remezov shows how Gedroits, on the basis of his experiments and the information in the literature, gradually succeeded in understanding the problem of the melioration of solonetzes and in posing and providing original solutions to a number of other questions (liming as a means of improving and increasing fertility of sod-podzolic soils with an acid reaction, interrelationships between soils and various fertilizers, formation of the soil structure, use of minor elements as fertilizers, etc.).

The chapter devotes considerable attention to the Swiss scientist G. Wiegner, who by his profound investigations produced a physicochemical explanation of the ionic-adsorption and exchange reaction in the coagulation and peptization of soil colloids. In attributing great importance to G. Wiegner's work, the author of this book stresses that, in contrast to that of Gedroits, it was not combined with parallel observations of plant growth under various physicochemical conditions in the medium. Wiegner worked with artificial preparations such as permutite (an artificial zeolite), so that the interesting results he obtained require supplementary investigations before they can be applied to conditions in the soil. Remezov also devotes much space and assigns great importance to the work of the Swedish scientist S. Mattson, which was directed mainly toward the nature of the adsorption complex in the soil rather than toward the exchange phenomenon. In Remezov's opinion, Mattson's chief claim to fame lies in his developing the theory of the amphoteric behavior of soil colloids and his physicochemical explanation of their property of adsorbing cations and anions under various conditions. During the last 20 or 25 years Mattson has investigated a very large number of hydro-physical, chemical and physicochemical properties of soil colloids.

The previous works by Mattson are exceedingly important for the understanding and further development of the behavior and transformation of mineral fertilizers, particularly phosphates, in the soil. However, these interesting investigations which were made on models under laboratory conditions, also cannot be applied in full measure to the conditions in the soil. This is why the results of Mattson's work, like the speculative work of S. Goy (in Germany) and others, have this far found little use in the development and improvement of the means of applying fertilizers in agricultural production. The author of this book evidently also agrees with this opinion, although it appears to the reviewer that he describes Mattson's studies without indicating the specific conditions under which they might be applied. The data from the latest investigations of the overcharging of specific soils have not been used.

The chapter on "Classification of the Kinds of Adsorption Capacity of Soils" presents I. Way's, Yu. Liebig's and A. N. Sabanin's data on the kinds of adsorption capacity, and, finally, the most detailed classification by Gedroits, who founded the study of the adsorption capacity of soils. As is known, Gedroits distinguished five kinds of adsorption capacity. The mechanical, physicochemical and biological adsorption capacities are more simply described by Remezov. His book, in fact, describes the physical adsorption capacity too schematically and without citing direct information on the molecular sorption of gases and vapors, so that the conception one obtains of this type of adsorption capacity of soils is not very clear.

The section on the chemical adsorption capacity should have contained several examples, instead of being limited to the single very partial case of phosphate precipitation in a soil containing gypsum; phosphates may also be precipitated in a soil that is merely rich in adsorbed calcium, as follows: $\text{Ca (soil)} + \text{CaH}_4(\text{PO}_4)_2 \rightleftarrows 2\text{H (soil)} + 2\text{CaHPO}_4$; $\text{Ca (soil)} + 2\text{CaHPO}_4 \rightarrow \text{H (soil)} + \text{Ca}_3(\text{PO}_4)_2$.

Remezov also cites other classifications of the types of adsorption capacity and exchangeable cations (those of G. Wiegner and Ye. I. Fervey), but he believes that the most successful is that of Gedroits and quite properly disagrees with the criticism by N. I. Gorbunov (Sel'khozgiz, 1948), which has no definite experimental basis. It is well known that the criterion of the physicochemical character of the cation-exchange reaction is its reversibility and equivalence. Only in this case may one speak of exchange adsorption and apply strict mathematical rules to the experimental materials. The author of this book does not satisfactorily explain this essential criterion.

The section of the book on the composition and structure of the adsorption complex in the soil cites Gedroits' definition of this concept as a colloidal system which also includes larger fractions of particles between 0. 001 mm and 0. 00025 mm in diameter; in the coagulated state, these particles combine with each other and with still larger particles to form aggregates. The text contains data on the adsorption capacities of the individual separates of the various soil forming parent materials, along with their chemical and mineralogical compositions. It must be said that the classification of clay[1] minerals adopted in this book is somewhat obsolete. It would have been better to use the more complete classification suggested by Grim (Ralph Grim, Clay Mineralogy, New York, 1953). The author cites a useful classification of the lattice structures of the most common silicates and aluminosilicates and of certain clay minerals from a book by A. G. Betekhtin. This section fails to include any of the existing data on the composition of clay minerals in specific soils and the concepts of the thermodynamic and electrokinetic potentials are not well presented.

After describing the inorganic part of the adsorption complex in the soil, the author moves on to the structure of the organic matter. He confines himself to describing the structure without explaining the concepts of phenol groups, hydrogen bonds, the oxyflavonic cell in the chain, etc. -- all these are only partially explained at various points in the book and thus create difficulties for the reader of this chapter. No consideration is given to the organic-mineral compounds of the adsorption complex in the soil.

---

[1] N. P. Remezov uses the term "clay minerals."

There is somewhat more detail in the account of the theory of the behavior of soil colloids and in the explanation of the structure of the colloid micelle according to the ideas of Wiegner, Mattson and Gorbunov. Some idea is given of the isoelectric precipitation of colloids under various conditions (pH, etc.).

The author's assertion that the isoelectric point can be determined only by cataphoresis (p. 48) is incorrect, since electroosmosis is more often used.

The chapter on "The Cation-adsorption and Exchange Reaction" sets forth the laws, as established by Gedroits, Wiegner and Gorbunov. These are: the physicochemical adsorption capacity of the soil; the adsorption and expulsion of cations and the importance in this process of the valence and the atomic weight of the ions; the magnitude of their radius and the degree of hydration; the thickness of the hydrated shell; the effect of the concentration and volume of the expelled solution; the concept of the energy involved in the outer- and intramicellar penetration and expulsion of various ions; and different opinions (those of Zyrin, Wiegner, Gorbunov and others) on the strength of the bonds formed by mono- and divalent cations with the adsorption complex of the soil. The reader will be disappointed that no general theories are given in regard to the last of this series of questions.

Remezov dwells in greater detail on the results of Gorbunov and Tsyurupa's work on the importance of the soil-solution ratio in the exchange of cations, but there is no critical analysis of the opposite behavior found by these two authors of the Ca, Mg and Ba cations in the exchange reactions under the conditions of dilution (Table 6 and Fig. 19), and of other anomalies.

Some perplexity will be caused by unusual physical terms in this section, such as: 1) "self-potential" instead of ionic potential, 2) "the density of the electric voltage" (p. 57), 3) "oxonium" instead of hydroxonium, 4) "activity of the solutions" instead of activity of the ions in the solutions, as well as the statement that it is possible to determine the potential by means of "the electrostatic charges" (p. 51).

The chapter on the "Cation-adsorption Capacity" defines this concept and mentions the factors that determine the magnitude of the adsorption capacity of the soil (the contents of the colloidal and pre-colloidal fractions; the nature of the adsorption complex in the soil, particularly its mineral composition and the structure of its minerals; the importance of the carboxylic groups and the phenol hydroxyls in the composition of the humus acids; etc.), in addition to presenting information on the relationships between the adsorption capacities of the mineral and the organic parts in different soils. Unfortunately, an error has evidently crept into Table 10 in converting the magnitudes of the adsorption capacities from gram-equivalents to milligram-equivalents per 100 grams of humus (so that the capacity reaches the improbable magnitude of 2450-7900 mg-eq, and in the mineral part 130-630 mg-eq, per 100 g).

This chapter makes extensive use of work done by Mattson and others in explaining the significance of the amphoteric behavior of the soil colloids, which determines the magnitude of the soil's adsorption capacity under various reactions of the medium. The concept and the magnitude of the pH for a neutral exchange reaction in the case of various adsorbing agents (aluminum and iron hydroxides, silica gel, humic acid, iron and aluminum humates, etc.) are given. The author shows the dependence of the soil's cation adsorption capacity on the reaction of the medium (the pH) and indicates that the adsorption capacity cannot have a constant magnitude. On the basis of data available in the literature, he cites certain quantitative expressions of the laws governing the exchange of cations, but without the necessary allowance for the degree of reversibility and equivalence of the cation exchange.

The chapter on "The Deficit of Cations in the Soil. Exchange and Hydrolytic Acidity of the Soil" is very thorough. One feels that the author not only has complete command of the literature on the subject, but by his experiments has made his own definite contribution to its development. This is why it seems to the reviewer that Remezov has been most successful in writing this chapter. This includes a detailed discussion of the soil acidity resulting from the exchange of ions and from hydrolysis (in papers by S. N. Aleshin, D. L. Askinazi, N. P. Karpinskiy, N. P. Remezov, I. G. Moiseyev, D. N. Pryanishnikov, V. A. Chernov, and especially J. di Gleria, Harward and others).

This section again cites the conceptions of di Gleria and other authors, without sufficient critical analysis.

After summarizing the previous papers and other information in the literature, the author makes an objective evaluation of the problem of the soil's acidity, from which one must conclude that certain controversial questions still remain to be solved.

The chapter on "Control of the Active Reaction (the Buffering Action of the Soil)" defines the buffering action of the soil solution and gives the formula for calculating the pH from the dissociation constant of weak dilute acids. There is a discussion of carbonic acid and its equilibrium with $Ca(HCO_3)_2$ at various values of the pH, and of the factors that determine the magnitude of the pH in acid and neutral soils. The buffering action in the soil is further explained, and various methods of determining it and expressing it in terms of a system of coordinates are described. Remezov agrees with "the essence of the remarks on the concept of the buffering action of soils" made by G. Kappen, who believed that the phenomenon designated by the words "buffering action of the soil" does not correspond to the physicochemical meaning of this term, and would have preferred the term "regulating." The reviewer cannot agree with this view or the reasons behind it; he believes that the term "buffering action of the soil" should be retained, since there is no need to introduce a new term.

The chapter on the "Adsorption of Anions by the Soil" contains examples of the chemical precipitation of phosphates in the presence of $Ca(HCO_3)_2$ in the soil solution, or in the case of a soil that is rich in adsorbed calcium.

The cases of the physicochemical adsorption of phosphates are based on the structure of the colloidal micelle as conceived by Wiegner; they were ultimately confirmed experimentally by a number of investigators, and may be easily explained in terms of Mattson's theory of the amphoteric behavior of the soil colloids. In the author's opinion, the soil's capacity for the physicochemical adsorption of anions may be judged by the pH and the curves of the exchange neutrality. Since these terms are not explained in the text they produce difficulties in reading this section of the book. The method suggested by Remezov is not the simplest and clearest. A comparison of the capacities for the adsorption of phosphates may be made by agitating various soils under identical conditions in a solution of dihydrogen phosphate of known concentration, and determining the remaining quantity of phosphorus in the equilibrium concentration.

This work contains practically no information on the soil's adsorption of sulphate, nitrate and chloride ions under various conditions, although such data are available in the literature. The data in Table 16 (p. 139) on the adsorption of phosphates by various soils (sod-podzolic and northern chernozem) require comment. The figures compel one to conclude that the soils studied show little difference in their phosphate-fixing capacities.

Later the author devotes much space to the mechanism of the adsorption of phosphates by various soils, and emphasizes the soils' capability of adsorbing phosphorus when they are saturated with sodium ions; this fact is evidence of the different nature of this adsorption of phosphorus from that of the original soils containing adsorbed calcium. This chapter also discusses the adsorption of phosphorus by various minerals and analyzes some other types of adsorption or fixation of phosphorus; these include "fixation by surface sorption" (according to S. N. Ivanov) and sorption according to the type of potential-determining ions along with the formation of a dielectric layer on the surfaces of the particles (micelles) and the simultaneous adsorption of the cation from the phosphate solution.

In discussing the role of the soil's adsorbed Ca in the adsorption of phosphorus, the author mentions the work done by R. Kh. Aydinyan, K. Scarseth, L. Allison and others, the results of which indicate that Ca ions play an undoubted role in the adsorption of phosphates. The author passes without comment over the works of V. M. Klechkovskiy and G. N. Zherdetskiy, who state that adsorbed Ca has nothing to do with the adsorption of phosphorus. In the reviewer's opinion, the latter authors conducted their experiments with such low concentrations of calcium that the conditions were not created for a precipitation of calcium to affect the phosphate ions.

In the following chapter, "The Exchangeable Cations, the Dispersed Condition and the Physical Properties of the Soil," the author traces the study of coagulation and peptization in the soil over the past century. He remarks that a great advance in the study of the coagulation of soil suspensions was associated with the investigations made by K. K. Gedroits, who based his conclusions on generalizations made from the data in the literature and from his own extensive scientific investigations, which made thorough use of the latest achievements in colloidal chemistry at that time (1912-1922); his most detailed study was that of the coagulation of clay suspensions by the effect of electrolytes. The author of this book cites Gedroits' main conclusions on this subject, and enumerates the factors that cause the coagulation of the colloids (the valence of the cations and their atomic weight, the freezing and desiccation of the soil, etc.) The hydroxyl ions have the opposite (peptizing) effect. In his exposition of the history of this question the author has made use of interesting papers and ideas by A. N. Sokolovskiy, A. F. Tyulin, G. Wiegner and others. It would have been desirable to mention the modern theories of the stability of hydrophobic and hydrophilic systems (in B. V. Deryagin, P. A. Rebinder and others). No use has been made of the extensive materials in R. Gallay (on the coagulation of clays), P. Tuorillo, etc.

It must be noted that in this part of the chapter the author uses a number of terms that require explanation: orthokinetic and perikinetic coagulation, critical potential, thixotropy, and others. It is also to the point to mention that the ideas on the thermodynamic and electrokinetic potentials presented on p. 18 of the book (according to information in the literature) are inaccurate.

The chapter mentions D. G. Vilensky's investigation on the significance of working the soil under moist conditions, approximately at plasticity state, from the rolling-out-to the liquid limit, in formation of the structural units in soil; it also mentions the work done by G. F. Nefedov, A. Puri, R. Kh. Aydinyan and others on the importance of crumbling the soil in separating the colloidal and precolloidal fractions. The value of the crumbling method as compared to Gedroits' method of peptization is exaggerated; according to the data in Table 20 in the book, the difference may be as much as 20% or more.

The chapter ends with a section on the effect of the cations on the physical properties of the soil, the plasticity and stickiness of soils, their dispersion, the so-called rolling-out-limit and other matters.

The next section covers the "Role of Colloids in the Creation of an Agronomically Favorable Soil Structure." Mention is made of the value of establishing water-stability and mechanical stability in the soil's structural elements. P. A. Kostychev's data on the great importance of the root systems of perennial grasses in creating a structure of small aggregates in the soil is also mentioned. These views were ultimately developed by V. R. Vil'yams. In the author's opinion, the role of colloids, and of the exchangeable cations contained in them, in the formation of the soil structure was most fully treated in Gedroits' works. There is an account of the work done by Antipov-Karatayev and his colleagues on the types of soil structures, in which the existence of two phases in the genesis of soil aggregates was established: 1) breaking up of the soil mass by alternate shrinkage and swelling into small aggregates, and 2) adhesion of these small aggregates by saturation with organic and inorganic "cements." As a result of this, the texture of most of the aggregates is close to that of the soil mass as a whole.

The chapter on the adsorptive capacity and the contents of exchangeable cations in the soils of the USSR contains a large amount of analytic material, including some by the author of this book, on the characteristics of different soils in this respect: data on the contents of adsorbed cations (Ca, Mg, H) and changes in these in different soil groups, and the degrees of their saturation with bases. Explanations are given of the cases in which, according to the results of the analyses, the hydrolytic acidity of the soil is less than the acidity of the exchange. In citing the data on the "dynamics" of the exchangeable cations during the period of vegetation, the author fails to give a critique of the methods by which these data were obtained.

The concluding chapter on "Vegetation and the Adsorption Complex in the Soil" analyzes the very important question of the availability of exchangeable cations to plants under various conditions in the soil.

Remezov's discussion of this question quite properly begins with a brief sketch of the investigations made by Gedroits, who devoted much of his efforts to this problem and collected a great deal of experimental data.

This chapter examines a number of papers on the interrelationship between root systems and exchangeable ions as a function of the latters' availability to plants (by D. A. Sabinin, Ye. I. Ratner, F. V. Chirikov, E. Russell, Lundegård and others) and on the means of changing the content of the exchangeable cations in the soil, and stresses the importance of these changes in soil fertility (by the introduction of lime, phosphates, gypsum and various mineral fertilizers, etc. into the soil).

It must be said, in conclusion, that this book will be of use in giving scientific workers and university teachers a broad acquaintance with the present state of the study of the soil's adsorption capacity -- a property that is of very great importance in studying the means of increasing the soil's fertility.

N. P. Remezov's book will ultimately be published in a new edition; it would therefore be desirable for the author to take account of these remarks made by the reviewer.

Reviewed by D. L. Askinazi and
I. N. Antipov-Karatayev

CHRONICLE

THE SEVENTIETH BIRTHDAY OF IVAN NIKOLAYEVICH ANTIPOV-KARATAYEV

Director, Laboratory of Physical Chemistry, V. V. Dokuchayev Soil Institute, Academy of Sciences, USSR

by the Editorial Staff of Pochvovedeniye

The first day of September, 1958, marked the completion of seventy years of life and thirty-five years of scientific activity by one of the most prominent Soviet soil scientists and chemists -- the distinguished scientific worker and active member of the Academy of Sciences of the Tadzhik Republic and Director of the Laboratory of Physical Chemistry in the V. V. Dokuchayev Soil Institute of the Academy of Sciences of the USSR, Professor Ivan Nikolayevich Antipov-Karatayev.

Ivan Nikolayevich's varied and extensive activities are widely known to scientific circles in the Soviet Union and abroad. He has published more than 220 papers on different problems of soil science and agrochemistry. Ivan Nikolayevich's scientific work has been most fruitful in the field of soil chemistry. In this area he and his colleagues have conducted a large number of investigations, the scientific value of which has repeatedly been highly rated in the literature of both our country and others. Through these investigations he has developed a number of original physicochemical methods of soil investigation which have found wide application in the solution of scientific and practical problems in soil science and agriculture (such as irrigation of the soils in the Transvolga region, melioration of saline soils, forestation of the soils in the arid Southeast, etc.). Despite the fact that most of these methods were developed twenty years ago or more, they still have not lost their scientific and practical importance. Among these, the most noteworthy are his electro-chemical colloidal-analytical methods of investigation (electrodialysis, electrophoresis, electrolysis, sorption of gases and vapors, character of the chemically bonded water, coagulation and peptization of the soil colloids, electrokinetic manifestations and overcharging of the soil, determination of the soil's unit surface). By his wide application of the principles of colloidal chemistry to his investigations of soils, I. N. Antipov-Karatayev was able to make a number of original contributions toward the understanding of the processes involved in the formation of soil aggregates (the nature of the soil structure), as well as the mechanism of the adsorption of ions by soils, clays and other adsorbents. This last series of investigations was closely associated with the problem of the soil's adsorption capacity and ionic exchange equilibria. In this area Ivan Nikolayevich and his colleagues produced numerous papers, which were the first to define the basic criteria for the equilibrium of ionic exchange reactions (exchange constants) and to establish the relationship of these criteria to the properties of the soil and the nature of the ions. Ivan Nikolayevich was one of the first to note the so-called hysteresis effect of the phenomena asso-

ciated with it. He has suggested the most successful method of studying the exchange adsorption of ions under dynamic conditions. This method has been used to study two complex problems: the mechanism of the exchange adsorption of anions, and the quantitative determination of the laws governing the exchange of ions with different valences (including ions with large nuclear masses).

An original method of studying soil solutions, widely used at the present time, was developed under his direction.

Of his publications, two fundamental works are especially important: "Soil Colloids and the Methods of Studying Them" and "The Melioration of the Solonetzes in the USSR."

I. N. Antipov-Karatayev's scientific interests have been extremely broad and many-sided. His many years of investigations in the area of the melioration of solonetz soils deserves special mention; these investigations are widely known not only in the Soviet Union but also in other countries. They include the theoretical elaboration of the problem of the formation of solonetzes, the genesis of the solonetzes in the USSR, the development of solonetz-forming processes in the chernozem zone (the Kamennaya steppe) and in the zone of semi-deserts, the methods of determining the salinity of soils, the melioration of solonetz lands under the conditions of arid cultivation and irrigation and numerous other studies.

Ivan Nikolayevich's pen has also produced a large number of edited articles, book reviews, reports, translations and popular works.

For several years I. N. Antipov-Karatayev took part in agrochemical investigations. He has published a number of papers on the nitrification of soils, the methods of determining the fertilizer requirements of podzolic soils, the methods of investigating humus and potassium, the adsorption of potassium and phosphorus ions by the soil, etc.

In addition to his physicochemical and agrochemical work, Ivan Nikolayevich has made a number of interesting studies in soil geography. His works on the soils of the Nikita Gardens and of the Taman' Peninsula (with L. I. Prasolov) and his investigations of the soils of the Transvolga area, Yergeney, Teberda, the Baksha Valley, the Eastern Pamir, Bulgaria and other regions are widely known to the literature of soil science.

In recent years he has devoted considerable efforts to organizing and carrying out investigations associated with the application of stable and radioactive isotopes to studies in soil science. The results of these investigations were reported to the International Conference in Geneva on the Peaceful Uses of Atomic Energy.

Ivan Nikolayevich has always strived to tie his theoretical and experimental investigations together with the tasks of applied soil science and agriculture. To this end he played an active part in the organization of the experimental station in the Kalmyk steppe, where methods of utilizing solonetz soils are being developed and the agricultural engineering aspects of irrigation are being studied. He is also doing extensive field work in the agricultural areas of Tadzhikistan, the Kamennaya steppe and other regions of the arid Southeast. He is studying the conditions of forest growth in the Yergeney, where large-scale experiments are being organized in the artificial forestation of the steppes.

Ivan Nikolayevich has devoted much effort and attention to the training of new specialists in soil chemistry. A number of doctoral and candidate dissertations have been produced under his direction.

Ivan Nikolayevich has combined his scientific activities with a great deal of common work on a number of journals, societies and in the Lenin All-Union Academy of Agricultural Sciences.

I. N. Antipov-Karatayev's extremely fruitful scientific work has been recognized by the government; he has been awarded three orders of the Red Banner of Labor and a number of medals.

I. N. Antipov-Karatayev faces his glorious seventieth birthday celebration with full creative powers and undiminished energies. It is hoped that he will achieve still greater successes in his efforts toward the development of Soviet soil science and that he will enjoy many more years of health and good spirits.

THE RESULTS OF THE THE FIRST INTER-OBLAST' CONFERENCE OF SOIL SCIENTISTS OF THE CENTRAL CHERNOZEM ZONE

P. G. ADERIKHIN

The First Inter-Oblast' Scientific and Productive Conference of Soil Scientists of the Central Chernozem Zone was held in Voronezh from April 2-4, 1958. The conference was attended by soil scientists, agrochemists and agronomists of the agricultural bureaus of the Voronezh, Tambov, Orlov, Lipets, Belgorod and Kura Oblasts, the oblast' agricultural experimental stations of the Central Chernozem Zone, and the V. V. Dokuchayev Agricultural Institute of the Central Chernozem Zone, the faculties, candidates, laboratory assistants and students in the Department of Soil Science of the Voronezh State University, and the faculties and candidates of the agricultural, forestry, veterinary and pedagogical institutes in Voronezh. The large and enthusiastic attendance at the conference bore witness to its timeliness and usefulness.

The conference was faced with the following tasks:

1. To put an end to the lack of unity between the work of soil scientists and agrochemists that has existed up to the present, and to establish permanent business-like contact between soil scientists working in the oblast' agricultural bureaus, scientific research and experimental agricultural institutes, and institutions of higher education.

2. To establish the creative collaboration between soil scientists and agrochemists and the agronomists in practical institutes and higher educational institutions is entirely necessary for the successful development of agrochemical soil science and the furtherance of agricultural production.

3. To acquaint productive workers in soil science with the latest achievements in the systematic classification of soils by the principles and methods of regional soil subdivision in soil erosion and its newest prevention methods, in large-scale soil photography and in the problems of soil fertility.

4. To share the experience derived from the practical and scientific work of soil scientists in the individual oblasts of the Central Chernozem Zone, and to find and eliminate the existing discrepancies.

5. To unify the classifications of the soils in individual oblasts of the Central Chernozem Zone and to create a single classification.

6. To unify the contents of large-scale soil maps, to decide the question of their practical use in kolkhozes and to fill in the gaps in soil mapping.

In accordance with these tasks, the following reports and joint reports were presented to the conference:

"The Fundamental Principles and the System of Soil Classification in the Chernozem Zone," by V. A. Nosin and I. P. Lovetskiy, A. S. Bukhtoyarova and M. N. Kikerin; "The Regional Subdivision of the Soils in the Central Chernozem Zone," by P. G. Aderikhin, I. P. Lovetskiy, V. N. Kochetov and V. I. Popov; "Soil Erosion in the Voronezh and Adjacent Oblasts and the Means of its Prevention," by M. S. Tsyganov, V. N. Kochetov, V. I. Popov and Yu. V. Pen'kovskiy; "Contents of Large-scale Soil Maps and their Use in Agriculture," by V. S. Goncharov; "The Soil Fertility in the Central Chernozem Zone and the Means of Increasing it," by A. A. Shoshin, N. Ye. Nazarov and M. P. Tevelev.

These reports were full of factual material and aroused lively interest on the part of the participants at the conference. All the reports produced resolutions aimed at improving the quality of the work done by soil scientists and increasing its effectiveness.

The conference worked out a unified classification of the soil throughout the entire area of the Central Chernozem Zone. The basis for this was the classification of soils proposed by the Joint Committee at the V. V.

Dokuchayev Soil Institute, Academy of Sciences, USSR and the working classification of soils of the Voronezh Oblast' agricultural administration. A single nomenclature for soils and their genetic horizons was also adopted. From this year on, the soil scientists of the Central Chernozem Zone, working in various institutions, will conduct their investigations in terms of a unified soil classification and nomenclature. The conference adopted the basic principles of regional soil subdivision and a single scale for all the areas of the Central Chernozem Zone. It was decided to mobilize all the means of pushing through a study of the soils of the collective and state farms, and on this basis to construct a map of soil and climatic districts with detailed information on the agricultural productivity of the soils in the various districts that are distinguished.

To generalize all this material, a working group was appointed which will later undertake the task of dividing the region into soil districts.

The conference of soil scientists devoted serious attention to the problems of soil erosion. Taking account of the particularly great importance of this question at the present time, the conference adopted a well-developed resolution and made practical suggestions.

The conference produced an active discussion of the contents of large-scale soil maps and their employment in agriculture. A resolution was adopted to unify the contents of soil maps and ways of integrating them into the agricultural production of the Central Chernozem Zone were planned.

In view of the fact that the Central Chernozem Zone occupies a prominent position in the agriculture of the RSFSR, and because of the importance of increasing the fertility of the Central Chernozem soils, the conference adopted a resolution requesting the Ministry of Higher Education to organize a scientific research soil laboratory at the Voronezh State University for the investigation of theoretical questions in the field of genetic and agronomic soil science.

It was also resolved to request the Ministry of Agriculture of the RSFSR to examine the feasibility of organizing departments of soil science and agrochemistry in the Oblast' agricultural experimental stations.

In order to raise the qualifications of the soil scientists working in the Oblast' agricultural administrations, the conference decided to request the Ministry of Agriculture of the RSFSR to organize a continuous course for increasing the qualifications of soil scientists similar to the courses for raising the qualifications of physicians, teachers and agronomists.

The Inter-Oblast' Conference of Soil Scientists was given the enthusiastic approval of workers in practical agriculture. It was thus decided to hold similar conferences annually, with the participation of the soil scientists in the Ministry of Agriculture of the RSFSR and the V. V. Dokuchayev Soil Institute of the Academy of Sciences of the USSR.

THE ACTIVITIES OF THE TURKMENIAN BRANCH OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS

O. M. DZHUMAYEV

The Turkmenian branch of the All-union Society of Soil Scientists was organized in February 1957. By January 1958 there were 35 members registered.

The branch is centralizing and coordinating the scientific research work of soil scientists and agrochemists scattered throughout the various institutions in the Republic.

At the present time the members of the Association, comprising the personnel of the Department of Soil Science of the Agricultural Institute in the Ministry of Agriculture of the Turkmenian SSR, are making preparations for the large-scale mapping of the collective and state farms of the Chardzhous Oblast'.

The members of the Association from the Institute of Hydrological Engineering and Melioration of the Ministry of Water Resources of the Turkmenian SSR are working on a solution to the problem of subdividing the Tashauz Oblast' into hydrographic districts. The soil scientists in the "Turkmengiprovodkhoz" Institute are making a soil survey in the area affected by the construction of the second course of the Karakum Canal and in the vicinity of the projected reservoir on the River Atrek.

Many soil scientists are participating in the development of long-term methods of soil improvement in the oases of Turkmenia (following a decree of the Council of Ministers of the Turkmenian SSR and the Central Committee of the Communist Party of Turkmenistan on July 1, 1957). The members of the Society, in addition to their work on scientific problems, are popularizing and publicizing scientific knowledge in the fields of soil science and agrochemistry among workers in agriculture.

O. M. Dzhumayev has composed a pamphlet on "The Local Fertilizers of Turkmenistan"; two papers (on the takyrs and the soils of the Obruchev steppe) have been printed in the Scientific Reports of the Turkmenian State University, and a course of lectures on modern agricultural subjects has been given. A. V. Yazykova has constructed a soil map of the second and third courses of the Karakum Canal, and the map has been sent to print. She has also written a talk, to be broadcast over the radio, on the subject of "Incrustation of the Soil and its Ways of Prevention." A. P. Lavrov, F. F. Trapeznikov and M. K. Charyyev have written a pamphlet on "The Soils of Turkmenistan." Preparations are being made for the printing of "Publications of the Turkmenian Scientific Research Institute of Agriculture," which will set forth the main results of an investigation of the soils in the zones of cultivation along the second and third courses of the Karakum Canal.

THE ACTIVITIES OF THE GEORGIAN BRANCH OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS

D. P. GEDEVANISHVILI

The Georgian branch of the All-Union Society of Soil Scientists at the present time has 60 members, who are working in scientific educational and production organizations.

The members of the Society are actively furthering the study of the soils of this country. At the request of the Ispolkom of the Shestiyskiy rayon, the staff of the Institute of Soil Science, Agrochemistry and Melioration of the Academy of Agricultural Sciences of the Georgian SSR made a study of the agricultural zone of Upper Svanetia in the summer of 1957. In connection with the projected construction of the Upper Alazan irrigation canal, a study was made of the soils in the areas to be irrigated.

The staff of soil scientists of the Ministry of Agriculture in 1956 and 1957 examined the soils in the Ochamchirskiy, Gal'skiy, Zugdidskiy, Tskhakayevskiy, Vanskiy and Mayakovskiy districts, in the interests of introducing crop rotation on the collective farms. In 1957 an examination was made of the soils of eight new wine-growing state farms.

At the direction of the Ministry of Agriculture of the Georgian SSR, M. N. Sabashvili constructed a map of the agricultural soil districts of the Georgian SSR, showing the areas of specialization in agriculture and the agricultural and soil characteristics of these areas. In order that the results of soil investigations might be used directly in collective and state farms, M. N. Sabashvili and his colleagues in the Institute of Soil Science drew up soil maps of the 68 administrative districts of Georgia and made subdivisions of 19 districts according to their agricultural and soil characteristics.

Under the direction of D. P. Gedevanishvili, the Department of Soil Science of the Georgian Agricultural Institute took part in the testing program for the selection of experimental areas. The All-Union Scientific Institute of Tea and Subtropical Cultures aided the Achigvarskiy tea-growing state farm in introducing measures to improve the water regime of the tea plantations and to increase the effective use of atmospheric precipitation. The Institute of Soil Science carried out a systematic program of helping the Makharadze collective farm to improve and make use of its saline and solonetz soils by deep plowing, introducing gypsum and planting perennial grasses (V. I. Chkhikvishvili and Ye. K. Tsintsadze), and also aided the Stalin collective farm at the village of Ninotsmida in the Sagaredzhiyskiy district in draining its swampy areas. Under the direction of the Institute's scientific personnel, the collective farm sowed an area of 300 hectares with winter wheat as a protection against wind erosion, and dug trenches over an area of 200 hectares to retard the surface erosion. The members of the All-Union Society of Soil Scientists (the staff of the Institute of Soil Science) published the following popular scientific pamphlets (in Georgian) during the period of the report: 1) I. G. Baratashvili, "The Soil and Its Fertility"; 2) V. V. Lezhava, "Micro-element fertilizers and their Role in Raising the Yield of Crops and Other Vegetation"; 3) Sh. F. Chanishvili, "Corn and Its Agricultural Engineering Aspects"; 4) P. Ya. Tadeosyan, "The Employment of Green Fertilizers in Soil Management"; and 5) N. T. Kvaratskheliya, "Increasing the Fertility of Orchard Soils." In addition, numerous articles were printed in the local popular magazines and district newspapers on the subjects of soil science and agricultural chemistry.

Members of the Department of Soil Science of the Agricultural Institute have published the following popular scientific pamphlets: G. P. Talakhadze, "Methods of Increasing the Effective Fertility of the Chernozems in Georgia"; and D. P. Gedevanishvili, "The Soils of the Corn-growing Areas of Georgia". M. K. Daraseliya has written the pamphlet, "Conclusions Drawn from the Experience of Pioneering Workers in Increasing the Fertility of Soils and Establishing Tea Plantations with High Yields."

ACTIVITIES OF THE GEORGIAN BRANCH

During the period of the report, the members of the Georgian branch of the All-Union Society of Soil Scientists have delivered more than twenty lectures at collective and state farms for the purpose of popularizing and spreading the scientific knowledge of soil science and agricultural chemistry. The members of the Society also act as consultants to production organizations on the matters of soil management and the use of fertilizers.

M. K. Daraseliya has acquainted himself with the soil and climatic conditions in the Federated People's Republic of Yugoslavia and has consulted with local workers on determining the prospects for the development of subtropical agriculture in Georgia, as well as acting as consultant to a number of scientific research institutions in Yugoslavia on organizing soil investigations and preventing soil erosion.

The members of the Georgian branch of the All-Union Society of Soil Scientists have also aided production by conducting training sessions in the various districts.

The members of the All-Union Society of Soil Scientists are integrating the results of their scientific investigations into agricultural production. A. S. Voznesenskiy and his colleagues have carried out a successful experiment in leaching very compacted solonchak-solonetz soils, as a result of which they have been able to de-salinize 100 hectares. At the present time the Institute of Hydrological Engineering and Melioration, together with a collective farm, is engaged in the soil leaching operation of the right bank in the Alazan valley and planting the eroded areas with orchards, melons, field crops and grasses.

The Institute of Soil Science has given instruction to the Ministry of Agriculture in the introduction of granular fertilizers and the proper use of the soils in the Sachkherskiy district in planting new vineyards. Fertilization systems and plans for their use have been worked out (by P. Ya Tadeosyan and V. V. Lezhava) for the Dimitrov collective farm at the village of Kvemo-Khandaki in the Kaspskiy district and the Stalin collective farm at the village of Ninotsminda in the Sagaredzhiyskiy district. The Ministry of Agriculture has been instructed in the means of improving the solonetz soils of the Saganluk plain, which will raise the yield of grain crops by 50-120%.

THE WORK OF THE KOMI SECTION OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS IN 1957

I. V. ZABOYEVA

The Komi section of the All-Union Society of Soil Scientists was ratified by the Organization Committee of the Society in March 1957. At the present time the section includes 34 members. The general meeting of the section elected a Presidium of the Komi section with five members.

In accordance with the section's agenda for 1957, which was adopted by the general meeting of the membership, the following things were done:

1. In honor of the fortieth anniversary of the Great October Revolution, in the Komi republic's regional museum the members prepared an exhibit on "The Soils of the Komi ASSR and the Results of the Soil Investigations during the Soviet Period." Some materials were given to the museum on the results of investigations by the Department of Soil Science on the effects of perennial grasses on the fertility of podzolic soils, and on the results of experiments in the north on the effect of fertilizers on the yields of floodplain meadow soils under Northern conditions. A soil map of the Komi ASSR was also given to the museum.

2. The members familiarized themselves with the educational program and the organization of training in soil science and agriculture in the Komi Pedagogical Institute and the Agricultural Technical School.

3. A course was organized in the Pedagogical Institute on problems of agriculture, which included discussions of soil science (D. A. Ostanevich).

4. The general meeting of the membership of the section discussed a report by N. V. Chebykinaya on "The Effects of Perennial Grasses on the Fertility of Podzolic Soils under the Conditions of the Komi ASSR."

5. In preparation for the All-Union Congress of Soil Scientists, a systematic list of the soils in the Komi ASSR was considered.

During the past year the soil scientists of the Komi section carried out the following planned projects:

a) an investigation of the soils in the Intinskiy and the Ust'Usinskiy districts, along with the construction of a medium-scale soil map; b) experiments were begun in the area of the "Bol'shoy Int" state farm on the floodplain of the River Kos'yu, to determine the effects of mineral and organic fertilizers on the plant yield of the floodplain meadows. The field studies of the soil in the Pechorskiy industrial district were completed during the past year. This material is being prepared for publication; c) in line with the subject of N. V. Chebykinaya's report on "The Scientific Basis of the Use of Agricultural Methods to Increase Soil Fertility," general conclusions were drawn from the results investigated in the years 1951 to 1955 on the nutrient regime in soils as affected by perennial grasses, and the agrochemical characteristics of the soils in the Komi ASSR were studied. T. G. Yurkina is studying the nutrients and the water and air regime in the soils of bare and covered fallow fields in the central part of the Komi ASSR. D. M. Rubtsov is summarizing the data on the Udorskiy district; d) besides the foregoing projects, the section is carrying on certain investigations in conjunction with other sections. A soil map with explanatory notes was drawn up by the Vil'gortskiy biological station of the branch of the Association. Further investigations (by L. A. Verkholantseva, L. N. Frolova and T. L. Bogdanova) are being made of the soils of cut-over areas to determine the means of improving their forest growth characteristics in regulating the reforestation of cut-over areas.

A great deal of work has been done in constructing a soil map of the experimental station of Lower Chova.

The book "Soils of the Komi ASSR" appeared in print during the past year.

THE WORK OF THE KIEV SECTION OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS

G. N. SAMBUR

The Kiev section of the Society of Soil Scientists was organized at the beginning of May 1957. The first general meeting of the members of the Association on May 3, 1957, was held to elect a board of officers of the section and adopt a plan of work for 1957. At the present time there are 176 members in the Association. The section unifies the major efforts of soil scientists and specialists in allied fields working in the scientific research, educational and production organizations of Kiev. Efforts are being made to bring workers in certain parts of the Oblast' and its surrounding areas into the Society. In particular, a group of soil scientists at the Chernov State University has been enrolled in the Society.

The section organized three committees: 1) genesis and mapping, 2) fertility and 3) melioration of soils. These committees heard a number of reports, some of which were presented at the First Congress of Delegates of Soil Scientists of the USSR.

During the period of the report; the section concentrated its activity toward rendering every possible aid and participating directly in the conduct of large-scale soil investigations and the construction of soil maps of the collective and state farms of the Ukrainian SSR, and in the simultaneous development of practical measures for rational land use and the improvement of soil fertility in each type of agriculture. This work is planned to continue for five years and to include all the collective and state farms of the republic within its scope. In view of the newness of this work, a group of the members of the Kiev section of the Association (G. N. Sambur, I. G. Zakharchenko, F. A. Popov, V. I. Drobot and others), on the basis of soil investigations, has elaborated and published sample notes and maps and steps to be taken in the scientific use and melioration of soils on the example of two collective farms (the Stalin collective farm in the Chernobyl'skiy district of the Kiev Oblast' and the "New Road" collective farm in the Chernigov district of the Chernigov Oblast').

The general meeting of the Society members heard and discussed a report by M. M. Godlin on "The Classification of Soils According to Their Textures." The section endorsed the principles set forth by Godlin and considers it necessary to hold a special meeting on this question at the V. V. Dokuchayev Soil Institute of the USSR Academy of Sciences to eliminate the deficiencies in A. N. Kachinskiy's classification and to work out a unified classification of soil textures.

Great interest was also aroused by G. N. Sambur's report on "The Results of the Work by the Joint Committee on the Classification of Chernozem Soils" and A. S. Skorolumov's report on "A Terminology of Eroded Soils and the Methods of Mapping them in the Field."

Many members of the Kiev section of the Society have traveled about the region to deliver popular lectures and reports on the soils of the Oblast', district or collective farm and measures of increasing their fertility.

In view of the need for a large amount of analytical work in soil investigations, the section has collaborated through its membership in the application of new and more advanced methods of soil analysis. Many soil laboratories in the scientific research institutes of the republic are presently achieving success in the introduction of the methods of flame photometry, electrophotocolorimetry and spectroscopy and are making extensive use of trilonometric methods.

The Kiev section of the Society is also aiding in the training of soil science specialists and in raising the qualifications of the members of the Association.

THE WORK OF THE ROSTOV SECTION OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS

P. A. SADIMENKO

The Rostov section of the All-Union Society of Soil Scientists began its work in 1946. Its efforts are directed mainly toward aiding soil scientists in studying the soils of the Don and the Northern Caucasus areas, in spreading popular knowledge of soil science and agricultural chemistry and in helping the Society members in their scientific and practical activities.

The following reports were heard and discussed at meetings of the section: "The Results of the All-Union Conference of Soil Scientists," "The Sixth International Congress of Soil Scientists," and "A New Soil Map of the USSR for Colleges and Universities."

Active meetings are held for the communication of materials on the study of local soils. The report by F. Ya. Gavrilyuk, for example, on the "Classification of the Soils of the Rostov Oblast'" called forth a lively exchange of opinions.

There was a no less thorough discussion of V. Z. Sergeyev's report on T. S. Mal'tsev's methods of soil treatment.

A great deal of attention was devoted to considering reports by production workers in soil science on the methods used in conducting their investigations. There was detailed discussing of the communications by N. N. Konovalov, director of the soil melioration section of Yuzhgiprovodkhoz and by M. M. Sugrobov, director of the soil department of the Administration for the Organization of Land Use. The exchange of experiences helped to improve the work of the organizations that are making studies of the soil.

The Society familiarized itself with the scientific investigations being made by soil scientists in the University. The following reports were heard in this connection: "The Subdivision of the Rostov Oblast' according to Agricultural and Soil Districts," by F. Ya. Gavrilyuk, and "The Soils of the Caspian Lowland in the Caucasus" and "Soils and Diseases," by V. V. Akimtsev.

Practical workers in agriculture and students, who took an active part in discussing the reports, were invited to the Society meetings. Thus, for instance, the discussion of Ye. P. Boychenko's report on "Protective Forestation in the Irrigated areas of the Rostov Oblast'" included Comrades Tkachenko, Makeyev and Ostrokopytov, representatives of the Agrolesoproyekt, and Comrade Poleshchuk and others, representing the Biological Institute. The report by P. S. Volkov (of the Glavvodkhoz of the Ministry of Agriculture of the USSR) drew the attention of soil scientists and workers in forest melioration. Much interest was aroused by M. S. Shul'man's report on "The Simplified Field Salinometer and the Field Photoelectric Nickel-Iron Colorimeter of the Physico-mathematical Scientific Research Institute of Rostov University." The participants at the meeting made a number of critical remarks on the construction of the apparatus. The simplified field salinometer has subsequently been used in the Yuzhgiprovodkhoz'es field work.

The Rostov section of the Society holds joint meetings with societies in related fields. On October 29, 1955, there was a joint meeting of the Biology and Soil Science faculty, the Society for the Propagation of Scientific and Political Knowledge, in honor of the 100th birthday of I. V. Michurin. At this meeting a report was read on "The Life and the Chief Phases in the Scientific Activity of I. V. Michurin." A joint session with the Botanical Society heard a report on the results of the All-Union Conference on the Utilization of Minor Elements. The annual meeting in March in honor of V. V. Dokuchayev is held jointly with the association of science students. Films on agricultural science subjects are shown constantly.

The Presidium of the section attaches great importance to consultation work. Consultations on problems in soil science and agricultural chemistry are arranged not only with members of the Society but also with all workers in agricultural science. The Society's members deliver lectures and reports to the general public. F. Ya. Gavrilyuk, V. V. Akimtsev,

. A. Sadimenko, and G. T. Kuleshov made rips to collective farms and soil-science field arties. B. G. Karnaukhov acted as consultant n problems connected with the use of fertilizrs. In assisting the Administration for the rganization of Land Use, a group of Society nembers studied the soils and made soil maps f collective farms in the Kuybyshev district nd the Kuybyshev and Ravnopol' Machine ractor Stations of the Rostov Oblast'. The soil nap of the Kuybyshev Machine Tractor Station vas displayed at the Oblast' agricultural exposiion in 1957.

The members of the Society take part in all he Oblast' meetings on agricultural problems nd in the work of the Zones Committee of the he Lenin All-Union Academy of Agricultural ciences in working out agricultural methods for the collective and state farms of the Lower Don region.

In 1957 the soil scientists in the Administration for the Organization of Land Use (M. M. Sugrobov, S. M. Akopyan, V. I. Butkova and others) drew up a soil map of the collective farms in the Rostov Oblast'. The soil scientists of the Yuzhgiprovodkhoz (K. I. Simantovskaya, I. Z. Osipova, A. N. Rudenko and others) made studies of the areas intended for irrigation in the Rostov, Stalingrad and Voroshilovgrad oblasts and in Stavropol and Dagestan, and also took part in the development of the complex water management systems. The soil scientists of the agriculture-forestry project (A. D. Grishin and others) developed measures of forest melioration for a number of districts.

THE WORK OF THE PENZA SECTION OF THE ALL-UNION SOCIETY OF SOIL SCIENTISTS

K. A. KUZNETSOV

The Penza section of the All-Union Society of Soil Scientists was organized in March 1957 and numbers thirteen members working in the Administration for the Organization of Land Use and in the Penza Agricultural Institute. In 1957 there were two general meetings of the members of the Society to discuss organizational problems and the agenda for 1957.

During 1957 the members of the Society, at collective farms, Machine Tractor Stations and district centers, delivered 79 lectures on the characteristics and soil improvement of individual collective farms, districts and oblasts. Some members of the Society took an active part in meetings of the Obkom, the Oblispolkom and the Oblast' Agricultural Administration on problems connected with the agricultural production of the Oblast'.

A group of Society members, soil scientists in the Administration for the Organization of Land Use, was engaged in soil mapping and the addition of explanatory notes to soil maps of Machine Tractor Stations and collective farms. Other members, working in the Penza Agricultural Institute, carried out analytical work for various organizations in the Oblast'. K. A. Kuznetsov worked out a program of making explanatory notes for district soil maps; he also acted as consultant to organizations, collective farms and state farms on problems associated with increasing the fertility and making effective use of the soil.

In 1957 the Society's members published a soil map of the Penza Oblast' and three scientific papers in the Publications of the Penza Agricultural Institute.

The members of the Penza section have concentrated their scientific researches on problems connected with the agricultural productivity of soils, the basis for increasing their fertility and their scientific use for agricultural production, by constructing soil maps for the collective and state farms of the Oblast'.

BIBLIOGRAPHY

SOIL FORMATION FACTORS, GENESIS, SOIL GEOGRAPHY

1. Agricultural and climatic handbook for the Saratov region. L., Gidrometeoizdat, 1958, 298 pages with maps.

2. Agricultural climatic handbook for the Tula region. L., Gidrometeoizdat. 128 pages, with maps.

3. Agricultural climatology. Edited by S. A. Sapozhnikova. Tr. N.-i. in-ta aeroklimatologii. Issue 2. M., Gidrometeoizdat. 1957, 116 pages, with illustr.

4. AFANAS'YEVA, YE. A. 1958. The chernozems of the Streletskiy steppe. Guidebook for the Organizational Committee of the All-Union Society of Soil Scientists. First Delegate Conference of Soil Scientists. M., 18 pages.

5. VOSKRESENSKIY, S. S. 1958. Problems of the geomorphology of Siberia. Author's summary of the dissertation for a Doctor's degree in the geographical sciences. Mosk. gos. un-ta. M., 30 pages.

6. GERASIMOV, I. P. and MA YUN-CHZHI. 1958. Genetic groups of soils and their geographical distribution in the Chinese Peoples' Republic. M., Izd. AN SSSR. 86 pages, with illustr, and 1 l. map.

7. Hydrogeological outlines of the virgin soils of the Aktyubinsk, Kokchetav and North Kazakhstan regions. Edited by U. M. Akhmedsafina. Alma-Ata, Izd. AN Kaz. SSR. 1958. 210 pages with illustr, and maps.

8. GLAZOVSKAYA, M. A. 1958. The weathering and initial soil formation in the Antarctic. Nauchn. dokl. vyssh. shkoly. Geol-geogr. nauki. No. 1:63-76, with maps.

9. GNILOVSKOY, V. G. 1958. Karst forms on the Stavropol' upland. Sb. tr. Stavrop. ped. in-ta. No. 11:53-68.

10. GNILOVSKOY, V. G. and V. N. SERGEYEV. Sagging phenomena in the Stavropol' area. Ibid, pp. 281-86.

11. DERIY, I. G. and G. YA. SEMCHENKOV. 1958. The Soils of the Belotserkovskiy arboretum, "Aleksandriya," and some results concerning the acclimatization of exotic trees. Nauchn. zap. Belotserkovsk. s.-kh. in-ta. No. 5:221-36, with maps.

12. IVANOVA, L. S. 1958. A hydrochemical experiment on the description of the landscape of the Volga muds. Thesis report read on Feb. 4, 1958. Byul. Mosk. o-va ispyt. prirody. No. 63. Otd. geol. 33(3):160.

13. KAYEYEV, T. S. 1958. The loess of the irrigated area of the Rostov region. Conditions of deposition and sagging. Author's summary of a dissertation for the Candidate's degree in the geological and mineralogical sciences. Mosk. un-t. M., 21 pages.

14. KIRICHENKO, N. I. 1958. Carbonate and gypsum concretions in loess. Izv. AN Arm. SSR. Ser. geol. i geogr. nauk. 11(2):81-85, with maps.

15. KRYUCHKOV, V. V. 1958. Hydro-thermal conditions within the upper limits of the sub-alpine and forest belts in the Khibin Mountains. Botan. zh. 43(6):876-89. Bibliog. p. 888-89.

16. LEONOVA, N. N. and N. I. LEONOV. 1957. The Golodnaya Steppe. Historical-geographic outline. Tashkent. Gosizdat. Uz. SSR. 74 pages, with illustr., and maps.

17. LUKASHEV, K. I. 1958. Basic lithologic and geochemical crust weathering.

Minsk. Izd. AN BSSR. 470 pages, with illustr.

18. LUPINOVICH, I. S. and A. KH. SHKLYAR. 1958. The Belorussian forest area. (Geographical outline). Belorussk. gos. un-t. Minsk. 103 pages, with illustr.

19. MAYSURYAN, A. N. 1958. The soils of the northern part of the Chkalov sub-district of the Kokchetav region. Author's summary of a dissertation for the candidate's degree in agricultural sciences. Mosk. s.-kh. in-t. 16 pages.

20. POLYNTSEVA, O. A. 1958. The soils of the southwestern part of the Kola Peninsula. M., -L., Izd. AN SSSR. 152 pages, with maps.

21. POPOV, V. P., A. I. LAN'KO, A. M. MARINICH, and V. V. PORVYKINA. 1958. Outline of the physical-geographical regions of the Ukrainian SSR. Nauchn. dokl. vyssh. shkoly. Geolog-geogr. nauki. No. 1:92-100, with maps.

22. The soils of the kolkhoz, "Novyy Shlyakh," in the Chernigov sub-district of the Chernogov region and measures to increase their productivity. Compiled from the results of a soil survey made by a party of soil scientists from the Kiev Institute of Water Management. Kiev. 40 pages, with maps.

23. The natural conditions and resources of Poles'ye. Tr. Konf. po voprosam razvitiya proizvodit. sil. Poles'ya USSR. No. 1. Kiev. Izd. AN Ukrainian SSR. 124 pages, with illustr.

24. SAFRONOV, I. N. 1958. The geomorphological features of sloping plains of the Northern Caucasus. Sb. tr. Stavrop. ped. in-ta. No. 11:3-30.

25. SERBENTAVICHUS, A. I. 1958. The sandy soils of south-eastern Lithuania for pine trees. Author's dissertation for a candidate's degree in agricultural sciences. Lit. s.-kh. akad. Kaunas, 26 pages.

26. SIDORENKO, A. V. 1958. Preglacial weathering on the Kola Peninsula, M., Izd. AN SSSR. Illustr. Bibliog. 30 refs.

27. SKRYNNIKOVA, I. N. 1958. The soil in the Podushkinskiy forest (Guidebook for the Organic Committee of All-Union Society of Soil Scientists. First Delegate Conference of Soil Scientists). M., 21 pages.

28. SLYADNEV, A. P. 1958. Climatic outline of the Altai Kray. Alt. kn. izd. 139 pages, with illustr. and maps.

29. Central Asia. Physical-geographic description Otv. red. E. M. Murzayev. In-t. Geogr. AN SSSR. M., Izd. AN SSSR. 648 pages, with illustr. and maps. Bibliog. p. 611-24.

30. TALAKHADZE. G. R. 1958. The chernozems of Georgia. Author's summary of a dissertation for the doctor's degree in agricultural sciences. Gruz. c.-kh. in-t. Tbilisi. Izd. Gruz. s.-kh. in-ta. 32 pages. Bibliog. 11 refs.

31. TROITSKIY, A. I. 1958. The gray forest soils of the Central Russian uplands (Guidebook for the Organic Committee of All-Union Society of Soil Scientists. First Delegate Conference of Soil Scientists. M., 27 pages.

32. TYURIN, K. D. 1958. 'The origin properties and fertility of the soils of the Khrenovoye area of Voronezh Oblast'. Author's summary of a dissertation for the candidate's degree in agricultural sciences. Voronezhsk. s.-kh. in-t. Voronezh.

33. UMAROV, M. U. 1957. The soils of Golodnaya steppe and their utilization. Tashkent. Izd. AN Uz. SSR. 38 pages. In Uzbek language.

34. CHERNOVALOV, M. D. 1958. Sagging in the loess-like soil materials on the Stavropol' upland. Sb. tr. Stavrop. ped. in-ta. No. 11:69-82, with maps. Bibliog. 27 refs.

35. SHIMANOVSKIY, L. A. 1958. The ground water in the agricultural areas in the southeastern part of the Perm' region and the possibilities for their utilization. Perm'. Kn. izd. 52 pages, with illustr.

36. SHIRINOV, N. SH. 1958. Eolian relief forms on the Apsheron Peninsula Izv. AN Azerb. SSR. Ser. geol.-geogr. nauk No. 3:103-14, with maps. Bibliog. 13 refs. Resume in Azerbaijan language.

37. BADEN, W. and R. EGGELSMANN. 1958. Über das Bödenklima verschiedener Hochmoorkulturen und sein Einfluss auf den Pflanzenwuchs (In German) Z. Acker-und Pflanzenbau. 106(2):127-52. Bibliog. 59 refs.

38. BIBELRIETHER, H. and G. S. SPERBER. 1958. Diluviale Bodenbildungen im Spessart (In German). Allgem. Forstzeitschrift. 13(30):421-24. Bibliog. 12 refs.

39. COALDRAKE, J. E. 1958. The coastal and sand dunes of Southern Queensland. (In English) Soil News. aust. Society Soil Science No. 2:21. Reference in Soils and Fertilizers. 1958. No. 4:1373.

40. GORHAM, E. 1957. The development of peat lands. (In English) Quart. Rev. Biol. 32:145-66.

41. DEL HANO., M. A. 1957. A phylogenetic and ecological classification of the soils of the world, including those of equatorial regions. An. edofol. y fisiol. veget. No. 16:857-65. (Spanish). Ref. in Soils and Fertilizers. 1958. No. 3:996.

42. OLSON, J. S. 1958. Rates of succession and soils changes on Southern Lake Michigan sand dunes. (In English) Bot. Gaz. 119(3):125-70. Bibliography 64 refs.

43. TAVERNIER, R. and G. D. SMITH. 1957. The concept of Braunerde (brown forest soil) in Europe and the United States. (In English) Advances Agron. No. 9:217-89.

SOIL MINERALOGY

44. MIKHEYEV, V. I. 1957. An X-ray mineral dector. M., Gosgeoltekhizdat. 868 pages, with illustration.

45. CAGLIOTI, V. 1957. Problems of the chemistry of clay minerals (In English) Agrochimica. No. 2:1-25.

46. FUNABIKI, S. and T. SAKAMOTO. 1958. Clay minerals in soils derived from various petrographical origin of Ehime Prefecture. (In English) Member Ehime University 3(6):165-78. Reference in Soils and Fertilizers. 1958. No. 4: 1303.

47. MACKENZIE, R. C. 1957. Modern methods for studying clays. (In English) Agrochimica. No. 1:305-27. Bibliography 52 References.

48. STEPHEN, I. 1958. Micro-mineralogy of soils. (In English) Science Progr. No. 46:317-22.

49. SWINDALE, L. D. 1957. Some recent advances in clay minerals research (In English) J. New. Zeal. Institute Chemical No. 21:128-38.

PHYSICAL PROPERTIES OF SOILS AND METHODS OF INVESTIGATIONS

50. Apparatus to measure soil moisture (From foreign literature). Radio 1958. No. 6:56.

51. BIKIS, L. O. 1958. The effect of microrelief of the soil surface on the soil's thermal regime in the Latvian SSR. Author's summary of a dissertation for the candidate's degree in agricultural sciences. Mosk. lesothekhn. in-t. Riga. 16 pages

52. Hydrological problems. (Collection of papers for the 75-th anniversary of Professor Ye. V. Bliznyak). M., Izd. Mosk. un-ta. 1957. 223 pages, with illustration and portrait.

53. GUREVICH. T. V. 1958. Soil temperature and its field measurement. 2-oye izd. L., Gidrometeoizdat. 8 pages, with illustration.

54. KASPIROV, A. I. 1958. Soil incrustation and measures to control it. Izd. 2-oye. M-L., Sel'khozgiz. 142 pages, with illustration.

55. KENESARIN, N. A. 1958. The formation of ground water systems in irrigated districts. From the example of the Golodnaya steppe. Author's summary of a dissertation for the doctor's degree in the geological and mineralogical sciences. (In-t. geol. AN Uz. SSR. Tashkent. 36 pages.

56. KIL'DEMA, K. T. 1958. The methods and results of a study on the strong content in the Estonian SSR soils. Author's summary of a dissertation for the candidate's degree in geographic sciences. Tartuskiy un-t. Tallin. 25 pages, with maps.

57. KIRVALIDZE, R. I. 1958. The effect of perennial grasses on structure and its stability in the cinnamon-brown soils of the Mukhranskiy valley. Author's summary of a dissertation for the candidate's degree in agricultural sciences. Gruz. s.-kh. in-t. Tbilisi. 19 pages.

58. KORMILINA, YE. G. 1957. The physical properties of the dry-land sierozems of the Samarkand region and changes in them caused by forest plantings. Tr. Tashkentsk. s.-kh. in-ta. No. 9:79-91. Bibliography 6 references.

59. LEVCHENKO, I. M. 1958. Vliyaniye glubokoy vspashki s pochvouglubleniyem na vodopronitsayemost' pochvy (the

effect of deep plowing with deep furrowing on the penetration of water into the soil) Zemledeliye. No. 8:36-7.

60. BIRRELL, K. S. and R. Q. PACKARD. 1958. Low temperature adsorption of various gases by soils (In English) New Zeal. J. Science. No. 1:70-82.

61. GRADWELL, M. 1957. Effects of animal treading on a wet alluvial soil under pasture. (In English) N. Z. Society Soil Science Procedure No. 2:37-9.

62. GREACEN, E. L. 1958. The soil structure profile under pasture. (In English) Austr. J. Agricultural Resource No. 9:129-37.

63. HODNETT, G. E. 1958. The effect of temperature and moisture during storage on the viability of grass seed. (In English) Tropical Agriculture No. 35:208-12.

64. HOFFMAN, I. and OTHERS. Thermogravimetry of soils. (In English) Chemical and Ind. No. 9:261.

65. HOMRIGHAUSEN, E. 1958. Untersuchungen über die Aggregation von Bőden und ihre Kennzeichung durch Schlagfestigkeitmessungen (In German) Z. Acker- und Pflanzenbau. No. 105:61-88.

66. LACHENBRUCH, A. H. 1957. A probe for measurement of thermal conductivity in frozen soils in place (In English) Trans. Amer. Geophys. Union. No. 38:691-97.

67. POOLE, D. M. 1957. Size analysis of sand by a sedimentation technique. (In English) Sediment. Petrol. No. 27: 460-68. Ref. in Soils and Fertilizers. 1958. No. 3:956.

68. RICKARD, D. S. 1957. A comparison between measured and calculated soil moisture deficit (In English) N. Z. J. Sci. and Technol. No. 38A:1081-90.

69. SCHÖNFELD. S. 1957. The practical assessment of soils. Classification of soils according to their moisture economy. Országos. mezögazd. Minöségrvizsg. int. évk. No. 3:49-63.

70. SHAW, R. and W. F. BUCHELE. 1957. The effect of the shape of the soil surface profile on soil temperature and moisture. (In English) Iowa State Coll. J. Sci. No. 32:95-104.

71. STOCKINGER, K. R. 1957. Movement of water in unsaturated soils. (In English) Ibid, pp. 272-73. Ref. in Soils and Fertilizers. 1958. No. 3:972.

72. VOMOCIL. J. A. 1957. Measurement of soil bulk density and penetrability. A review of methods (In English) Advances Agron. No. 9:159-75.

SOIL CHEMISTRY AND METHODS OF ANALYSIS

73. ALESHIN, S. N. and B. F. KALEGANOV. 1958. The determination of the water-soluble salts of soils by the electrical conductivity method. Izv. Timiryazevsk. s.-kh. akad. No. 3:229-32.

74. ARTYUSHIN, A. M. and P. G. KUDELYA. 1958. A comparison between the polarographic and colorimetric methods to determine nitrates in the soil. Udobreniye i urozhay. No. 7:20-24.

75. KOREN'KOV, D. A. 1958. Determination of ammonia and nitrates in the soil. (The micro-diffusion method and Bremner and Shaw's modification. Ibid, No. 8: 57-58.

76. MAKHOVKA, P. P. 1958. The determination of available nitrogen in soils. Nauchn. zap. Belotserkovsk. s.-kh. in-ta. No. 5:281-83.

77. Methods to determine a micro-element in soils and plants. (Collection: chief editor, V. A. Chernov) M., Izd. AN SSSR. 80 pages.

78. PEYVE, YA. V. and G. YA. RIN'KIS. 1958. Field laboratory to determine the micro-elements (Cu, Zn, Mn, Mo. and B) available to plants. Riga. Izd. AN Latv. SSR. 24 pages, with illustr. Bibliog. 10 refs.

79. PETROV-SPIRIDONOV, A. YE. 1958. Use of the polarographic method in physiological and agricultural-chemical studies. (Determination of nitrates, phosphates, potassium and calcium). Izv. Timiryazevsk. s.-kh. akad. No. 3:223-28. Bibliog. 6 refs.

80. PSHEBEL'SKIY, V. V. 1958. Conditions for the intake into the soil of fall and winter precipitation. Zemledeliye. No. 8:32-35.

81. FEDOROVSKIY, D. V. 1958. Evaluation of methods to determine available potassium in chernozems. Udobreniye i urozhay. No. 7:16-19.

82. BOKEN, E. 1958. Determination of the

available manganese content of the soil. Tidskr. Plantcavl. No. 62:149-54. Ref. in Soils and Fertilizers. 1958. No. 4:1291.

83. DALBRO, S. and G. NIELSEN. 1958. Soil-nitrate investigation in orchards. Ibid, pp. 1-25.

84. EDWARDS, G. H. 1956. Changes in the solvent-soil ratio and the available phosphate figure in soil analysis (In English) Agric. Prog. No. 31:45-55.

85. GARTEL, W. 1957. Studies on the copper content of vineyards and vineyard soils. Weinberg u. Keller. No. 4:221-29.

86. HEMWALL, J. B. 1957. The fixation of phosphorus by soils. (In English) Advances Agron. No. 9:95-112.

87. HOBBS, J. A. and P. L. BROWN. 1957. Nitrogen and organic carbon changes in cultivated Western Kansas soils. Kans. agric. (In English) Exp. Sta. tech. Bull. No. 89, 48 pages, Ref. in Soils and Fertilizers. 1958. No. 4:1298.

88. HOGG, D. E. 1957. The assessment of available potassium in soils (In English) N. Z. J. Sci. and Technol. No. 38A: 1015-24. Ref. in Soils and Fertilizers. 1958. No. 3:895.

89. HUTTON, J. T. 1957. Exchangeable sodium in alkaline and saline soils. (In English) Soil News. aust. Soc. Soil Sci. No. 2:24.

90. MARTIN, R. P. and OTHERS. 1957. Discrimination between strontium and calcium in plants and soils. (In English) In the book Repr. UNESCO int. Conf. Radioisotopes sci. Res. Oxford. 15 pages.

91. MEINSEHEIN. W. G. and G. S. KENNY. 1957. Analyses of a chromatographic fraction of organic extracts of soils (In English) Analyt. Chem. No. 29:1153-61.

92. MOROZOV, J. and N. BĂJESCU. 1957. The content of copper and its distribution in the profile of some soil types of the R. P. R. (In English) An. Inst. Cercetări agron. Român. No. 24:31-46.

93. RAUPACH, M. 1957. Investigations into the nature of soil pH. C. S. I. R. O. (Australia). (In English) Soil Publ. No. 9:35 pages. Ref. in Soils and Fertilizers. 1958. No. 3:871.

94. SIMMONSON, G. H. and OTHERS. 1957. Free iron distribution in some poorly drained prairie soils in Iowa. Proc. Iowa. Proc. Iowa Acad. Sci. No. 64:385-92 (In English) Ref. in Soils and Fertilizers. 1958. No. 4:1292.

95. STANESCU, D. 1957. Polarographic and photocolorimetric microdetermination of copper, lead, nickel, zinc, cobalt, and manganese in soil. Stud. cercet. Chim. Cluj. No. 8:75-85. Ref. in Soils and Fertilizers. 1958. No. 4:1331.

96. JACKSON, M. L. 1958. Soil chemical analysis. New Jersey. 498 pages (In English) Ref. in Soils in Fertilizers. 1958. No. 4:219-20.

97. VUORINEN, J. 1958. On the amounts of minor elements in Finnish soils. Maatalous. Aikak. No. 30:31-35. Ref. in Soils and Fertilizers. 1958. No. 4:1296.

98. WOOD, G. A. and R. E. STANTON. 1957. A rapid method for the determination of chromium in soils for use geochemical prospecting. (In English) Trans. Instn. Min. Metall. Lond., No. 66:331-40.

SOIL BIOLOGY AND MICROBIOLOGY

99. ARISTOVSKAYA, T. V. and O. M. PARINKINA. 1958. The seasonal changes and ecological features of the microflora of some podzolic soils. Mikrobiologiya 27(3):324-30. Bibliog. 5 refs.

100. ARNOL'DI, K. V. and M. S. GILYAROV. 1958. The soil fauna from Mediterranean habitats in the Northwestern Caucasus and its importance to their description. Zool. zh. 37(6):801-19. Bibliog. p. 818-19.

101. BELYAYEV, G. N. 1958. The effect of continuous use of fertilizers on the microflora in sod-podzolic, aggregated-sandy soil. Mikrobiologiya. 27(4):472-77. Bibiog. 9 refs.

102. BUTKEVICH, K. P. 1958. The effect of manganese on soil microflora. Byul. po fiziol. rasteniy. Ukr. in-t. rasteniy. No. 3:67-71. Bibliog. 11 refs.

103. Problems of soil microbiology Tr. in-ta mikrobiol. AN Latv. SSR. No. 7. Izd. AN Latv. SSR. 1958. 175 pages, with illustr.

104. GILYAROV, M. S. 1958. Embii of the European part of the USSR, their systematic placement and significance for determination of Black Sea soils.

Byul. Mosk. o-va ispyt. prirody. No. 63. Otd. biol. No. 2:93-97. Bibliog. pp. 97.

105. GROMYKO, YE. P. 1958. Structure formation and microorganisms in podzolic soil. Mikrobiologiya. 27(4):465-71. Bibliog. 16 refs.

106. GUKASYAN, A. B. 1958. An instrument to seed the soil with micro-biological cultures. Mikrobiologiya. 27(3):393-95.

107. KOLKER, I. I., YE. N. DAKHNOVA. and M. N. PATENKOV. The effect of plowing on some of the microorganisms in the soil of fallow field Ibid, pp. 340-47. Bibliog. 10 refs.

108. KRASIL'NIKOV, N. A., A. A. DROBKOV, and O. G. SHIROKOV. 1958. The storage of naturally-radioactive elements by soil microorganisms. Dokl. AN SSSR. 120 (5):1136-7.

109. N'YUKHOLL, A. G. 1958. (Newhall) Disinfecting the soil by heating, flooding fumigation. Translated from the English by N. S. Shcherbinskiy. The Editing and introduction by M. S. Dunin. M., Izd. Inostr. lit. 94 pages.

110. CHUNDEROVA, A. I. 1958. Improving the conditions for development of nitrogen bacteria in the rhizosphere of a plant in acid soil-podzolic soils and increasing the effectiveness of the nitrogen bacteria by including organic-mineral mixtures. Author's summary of a dissertation for the candidate's degree in the biological sciences. Vses. n.-i. in-t. s.-kh. mikrob. L., 16 pages.

111. YUZHINA, Z. I. 1958. O zavisimosti mezhdu toksicheskimi svoystvami pochv Kol'skogo poluostrova i kolichevstvom mikrobovantagonistov k azotobakteru The relationship between the toxic properties of the soils on the Kola Peninsula and the number of microbe antibodics with the nitrogen bacteria. Mikrobiologiya. 27(4):460-64. Bibliog. 7 refs.

112. ALLEN, O. N. 1957. Experiments in soil bacteriology. (In English) Minneapolis, 117 pages.

113. BHARUCHA, F. R. and B. V. WAGLE. 1957. Effect of storage on nitrifying capacity of soils. (In English) J. Univ. Bombay. No. 25B:45-51. Ref. in Soils and Fertilizers. 1958. No. 4:1396.

114. BROWN, M. E. 1958. Preliminary studies on the inoculation of selected microorganisms into partially sterilized soils. (In English) J. Gen. Microbiol. No. 18:239-47.

115. ELKAN, G. H. and OTHERS. 1958. Relationships between differential plate counts, CO_2 evolution and organic matter decomposition in soil. (In English) Bacteriol. Proc. No. 58:7.

116. GELLÉRT, J. 1957. The ciliate fauna in some soils of deciduous and coniferous forests in Hungary. Ann. Inst. biol. (Tihany). Hung. Acad. sci. No. 24:11-34.

117. HERNDON, W. 1958. Studies on chlorosphaeracean algae from soil. (In English) Amer. J. Bot. 45(4):298-307.

118. KESSLER, E. and OTHERS. 1957. The influence of manganese and phosphate on delayed light emission, fluorescence, photoreduction and photosynthesis in algae (In English) Arch. Biochem. and Biophys. Chicago. pp. 321-35.

119. OTTEN, R. J. and OTHERS. 1957. Effects of several herbicides on nitrification in soil. From the book Proc. Northeast Weed Control. Conf. N. Y. pp. 120-27. (In English)

120. ROCHE, A. 1958. Activation biologique des sols carénces en P, par addition de phosphates naturels (In French) Ann. Inst. Pasteur. No. 94:673-78.

121. UNGER, H. 1957. Ein Bohrer zur Entnahme von Bodenproben für mikrobiologische Untersuchungen (In German). Arch. Mikrobiol. No. 27:429-32.

SOIL FERTILITY, FERTILIZERS, AND TILLAGE

122. ALEKSANDROV, V. G. 1958. Organic-mineral fertilizers and silicate bacteria. Dokl. Vses. akad. s.-kh. nauk. No. 7:43-8. Bibliog. 10 refs.

123. ASAROV, KH. K. 1958. The problem of boron uptake by plants when acid soils are limed. Izv. Timiryazevsk. s.-kh. akad. No. 3:153-66. Bibliog. pp. 165-66.

124. BALABAN, F. N. 1958. The effectiveness of organic-mineral mixtures. Zemledeliye No. 8: 37-39.

125. VIGOROV, L. I. 1958. Uskorennyy metod otsenki obespechennosti rasteniy pshenitsy azotnym i fosfornym pitaniyem (A quick method to evaluate the adequacy of nitrogen and phosphorus nutrients for

wheat. Udorbreniye i urozhay, No. 7:29-35.

126. VISHNEVSKIY, V. V. 1958. Improvement of the soil moisture under winter wheat as one of more important means to increase its crop on the southern arid steppe. Nauchn. tr. Odessk. s.-kh. opytn. st. Odessa. pp. 13-24. Bibliog. 12 refs.

127. VLASENKO, YE. A. 1958. The effect of fertilizers on the agricultural chemical properties of soil and the cotton yield where there is crop rotation. S. Kh. Uzbekistana. No. 5:14-19.

128. GROSHEV, N. A. 1958. Changes in the potassium regime of chernozem under continuous application of fertilizers. Author's summary of a dissertation for the candidate's degree in agricultural sciences. Leningr. s.-kh. in-t. M., 19 pages.

129. GULYAKIN, I. V. and A. V. KOROVKINA. 1958. The assimilation of phosphorus from fertilizers by plants in relation to time of application and soil properties. Izv. Timiryazevsk. s.-kh. akad. No. 3:91-104. Bibliog. pp. 103-4.

130. DUGIN, N. 1958. The use of the Magnitskiy Laboratory under industrial conditions. Udobreniye i urozhay. No. 7:36-8.

131. YEGOROV, V. YE. and B. A. DOSPEKHOV. Effectiveness of liming with continuous application of fertilizers. Ibid, No. 8:19-28.

132. ZHENATOV, A. P. and L. S. ROKTAEN. The economical effectiveness of using peat as a fertilizer. Ibid, pp. 44-46.

133. ZELENIN, N. N. 1958. Effectiveness of phosphorus fertilizers prepared from raw apatite (for cotton). S. Kh. Uzbekistana. No. 5:32-35.

134. KOCHERGIN, A. 1958. Effectiveness of organic and mineral fertilizers in Western Siberia. S. Kh. Sibiri. No. 6:28-33.

135. METEL'SKIY, F. I. and N. K. ZUBAREVA. 1958. Mal'tsev's methods of cultivation in the northeastern non-chernozem zone. Zemledeliye No. 7:18-21.

136. NAGIBIN, YA. D. and R. MAKHMUDOV. 1958. The effect of soil cultivation by the T. S. Mal'tsev method on the development of the root system and cotton crop. S. kh. Tadzhikistana. No. 5:17-25.

137. ONIANI, O. G. 1957. Conditions for effectiveness of potassium fertilizers on the tea plantations of Western Georgia. Byul. Vses. n.-i. in-ta. chaya i subtrop. Kul'tur. No. 3:23-43. Bibliog. 32 refs.

138. Methods to increase the fertility of the Udmurtskiy ASSR soils. Sb. statey. Izhevsk. Udmurt. kn. izd. 1958. 140 pages, with illustr.

139. RESHETNIKOV, F. I. 1958. Studying methods of introducing phosphorus under cotton. S. kh. Uzbekistana. No. 5:28-31.

140. SEMCHENKOV, G. YA. 1958. Properties and fertility of the soils on the Ros' River flood plain. Nauchn. zap. to Belotserkovsk. s.-kh. in-ta. No. 5:211-19. Bibliog. 16 refs.

141. USTINOVA, A. V. 1958. The effect of different methods of cultivation on the fertility of salinized soils. S. kh. Povolzh'ya. No. 7:36-39.

142. Phosphorus fertilizers. Collection of articles. Edited by A. V. Sokolov and D. V. Khar'kov. N. in-t. po udobr. i insektofung. No. 159. M., Goskhimizdat. 212 pages, with illustr.

143. TSERLING, V. V. 1958. A new instrument to diagnose plant nutrition. Udobreniye i urozhay. No. 7:25-28, with tables.

144. CHIZHEVSKIY, M. G. and M. A. KOROVKin. 1958. The effectiveness of liming acid soils containing various percentages of exchangeable alluminum. Izvestiya Timiryazevskiy s.-h. akadem., vyp. 3: 137-152. Bibliography of eight-refs.

145. CHIZHEVSKIY, M. G. and I. K. MAKARETS. 1958. Determination of the depth and frequency of cultivation using soil composition and structure as indicators. Zemledeliye. No. 7:10-18.

146. CHIKALIKI, G. M. and L I. ZAKHODYAKINA. 1958. Multistage systems of soil cultivation. Nauchn. tr. Odessk. s.-kh. opyt. st. Odessa. pp. 42-51.

147. SHEVYAKOV, A. D. 1958. The soil-agrocultural chemical map of the Kolkhoz zone of the Yeremovskiy machine Tractor Station MTS of Tul'a region, and its utilization in the rational use of fertilizers. Author's summary for a dissertation for the Candidate's degree in the agricultural sciences. Mosk. S,-kh. akad. M., 15 pages.

148. SHMIDT, R. A. 1958. The cultivation of

solonetz Novosibirsk. kn. izd. 50 pages, with graphs.

149. YUDIN, F. A. 1958. Povysheniye effektivnsoti fosfatov pri deystvi izvesti i domennogo shlaka na raznykh tipakh pochvy (An increase in the effectiveness of phosphates during the action of lime and blast-furnace slag on various soil groups. Izv. Timiryazevsk. s. kh. akad. No. 3:127-36. Bibliog. p. 136.

150. BURNSIDE, D. S. and M. B. STURGIS. 1958. Soil phosphorus and its fractions as related to response of sugar cane to fertilizer phosphorus. (In English) Bull. Agric. Exper. Sta. No. 513:30. Economic and technical analysis of fertilizers innovations and resources use. (In English) Iowa State Coll. press. 1956. 390 pages.

151. GOODE, J. E. and G. C. WHITE. 1956-57. Soil management effects on a number of chemical and physical properties of the soil. (In English) E. Malling Res. Sta. Rep. p. 113-21.

152. HIGNETT, T. P. 1958. Better nitrogen recovery. (In English) Farm Chemicals. 121(6):41-48.

153. HOORN, J. W. 1958. Results of a ground water level experimental field with arable crops on clay soils. (In English) Netherl. J. Agric. Sci. No. 6:1-10.

154. KÖHNLEIN, J. 1957. Ertragssteigerung, Nährstoffbilanz und Bodenuntersuchungsergebnis in Statischen Feldversuchen mit steigenden P_2O_5 und K_2 – Gaben (In German) Z. Acker-und Pflanzenbau. No. 104:229-56.

155. KÖHNLEIN, J. and N. KNAUER. Die Entzugszahl als Hilfsmittel zur richtigen Bemessung der P_2O_5 – und K_2O – Gabe (In German) Ibid, pp. 329-70.

156. LOIZIDES, P. A. 1958. Fertilizer requirements in Cyprus. 4. Effect of different types of phosphatic fertilizer (In English) Emp. J. Exper. Agric. 26(103):240-46.

157. MANN, H. H. Field studies in green manuring. (In English Ibid, pp. 274-82.

158. MARX, K. H. 1958. Enfluss von Beregnung und Humusdüngung auf den Boden (In German) Mitt. Dtsch. Landwirtschafts-Ges. 73(31):812-13, 73(35):912-13.

159. MCDERMID, J. 1958. Looking for richer soils. (In English) Better Crops. 42(5): 3, 22, 23.

160. MANGENOT, F. 1957. Acidité ionique et populations fongiques des bois. 2. Influence des conditions de culture sur la croissance et la synthèse des acides humiques. (In French) Rev. gen. bot. No. 64:670-77.

161. MÜLLER, G. 1956. Untersuchung über die Wechselbeziehung zwischen Bodenleben und Standortfaktoren ber Futterpflanzenarten (In German) Wiss. Z. Humboldt - Univ. Berlin. Math. – naturwiss. Reihe. No. 5:191-230.

162. PRETTY, K. M. and W. W. MCCALL. 1957. The effect of three liming materials on soil reaction and the yield and phosphorus uptake of alfalfa. A greenhouse study. (In English) Mich. ægric. Exp. Sta. quart. Bull. No. 40:318-26. Ref. in Soils in Fertilizers. 1958. No. 4:1539.

163. RID, H. and A. SÜSS. 1958. Die Berteilung von P^{32} im Boden und dessen Aufnahme durch Sommergerste bei verschiedener Bodenbearbeitung. (In German) Landwirtsch. Forsch. 11(1):40-44.

164. SCHEFFER, F. and OTHERS. Untersuchungen des Bodens auf Manganbedürftigkeit nach der mikrobiologischen Testmethode mittels Aspergillus niger. 2. Mikrobiologischer Nachweis von Mangan in Naturlichen Boden. (In German) Landwirtsch. Forsch. No. 10:207-14.

165. STEEN, E. 1957. The effect of aspect and slope on vegetation and soil in a natural pasture. In the book: St. Jordbr. Förs. Medd. No. 86. 54 pages. Ref. in Soils and Fertilizers. 1958. No. 1:226.

166. VON ZÖTTL, H. 1957. Untersuchungen über die Stickstoffnachlief erung des Waldbodens (In German) Mitt. bayer. Staatsforstverw. 29:73-80.

167. VALMARI, A. 1957. Bedeutung der Phosphorsäure für die Ertragsfahigkeit nordfinischer Moorböden (In German) Phosphorsäure. No. 17:171-82.

168. JACKSON, T. L. 1958. Fertilizing for maximum yields. (In German) Better Crops. 42(5):36-41.

INDEX OF MATERIAL PUBLISHED IN 1958

TABLE OF CONTENTS NOS. 1-12

Number

ALEKSANDROVA, L. N. and M. NAD', The Nature of Organo-Mineral Colloids and Methods of Their Study 10

ALEKSEYEVA, D. M., Effect of Soil Liming on Phosphorus Assimilation by Plants . . 10

ANDREYEVA, YE. A., The Influence of Various Methods of Deepening the Surface Soil on the Agrochemical Properties of Peat-Podzolic Soils 4

ARISTOVSKAYA, T. V., The Decomposition of Fulvic Acids by Microorganisms 11

ARMAND, D. L., Preventing Erosion from Hollows and Gullies by Tree Belts Along Their Brows 2

ASKINAZI, D. L., The Possible Role of Microorganisms in Increasing the Effectiveness of Ground Rock Phosphate as a Fertilizer 4

BASILEVICH, N. I., The Minor Biological Cycle of Ash Elements and Nitrogen in the Processes of Meadow-Steppe and Steppe Soil Formation 12

BIRYUKOVA, A. P., The Role of Afforestation in Decreasing Salinity of Irrigated Soils 8

BOBRITSKAYA, M. A., The Role of Annual Cultivated Plants in the Balance of Organic and Mineral Substances in the Soil 1

BOGATYREV, K. P., "Smolnitsy" (Smonitsa) of Albania (Cinnamon-Brown Meadow and Meadow Cinnamon-Brown Dark-Colored Magnesium Solonetz-Like Soils) 4

BOYLSHEV, N. N. and M. V. SOLOV'YEV, Soil Investigation Methods on State Farms Organized on Virgin Soil 4

BUD'KO, YE. N., Salinization of Soils in the Azov Irrigation System Area, Rostov Region 4

CHERNIKOV, F. S., Temperature Relations in Light-Chestnut Yergeni Clay Loam in Fields and Under a Shelterbelt 4

CHIZHEVSKIY, M. G. and L. P. CHARUYSKAYA, Some Results of Studies of Certain Soil Fertility Elements in Field Crop Rotations in Southern Kuban 7

DI GLERIYA, YANOSH, Physicochemical and Colloidochemical Processes Occurring in Soils Based on Latest Research 10

INDEX

	Number
DOLOTOV, V. A., Genesis of Mountain-Steppe Fragmentary Soils of Kopet-Dag	7
FEDOROVSKIY, D. V., Secretion of Labelled Phosphorus and Calcium From the Roots Into the Soil in Root-Fed Plants	3
FLORYA, N. and L. STOYKA, Some Characteristics of Salt Accumulation in Soils of the Northeast Rumanian Plain	8
FRIDLAND, V. M., Podzolization and Illimerization (Clay Migration)	1
GENDEL'MAN, A. M., Development of Soil Erosion Processes and Their Control in the Southern Steppe of Ukrainian SSR	8
GERASIMOV, I. P., The Principal Genetic Types of Soil in China and Their Geographic Distribution	1
GERASIMOV, I. P. and YE. N. IVANOVA, Comparison of Three Scientific Trends in Resolving General Questions of Soil Classification	11
GOLETIANI, G. I., Effect of Continuous Application of Fertilizers on the Properties of Krasnozems and Productivity of Tea Plantations	2
GROMYKO, I. D. YE. V. KULAKOV, A. P. MERSHIN and N. P. PANOV, Fertility of Virgin and Old-Cultivated Soils of Northern Kazakhstan	7
IVANOVA, YE. N., et al., Geographic-Soil Regionalization of the USSR	10
IVANOVA, YE. N., YE. V. LOBOVA and A. N. ROZANOV, Review of Papers on Soil Genesis in Vol. V of the Proceedings of the Sixth International Congress of Soil Science	5
KARAVAYEVA, N. A., High-Mountain Soils of the Eastern Sayans	4
KARAMANOV, I. I., Some Distinctive Genetic and Provincial Characteristics of Typical Chernozems of the Northwest Altai	3
KARPINSKIY, N. P. and V. B. ZAMYATINA, The Phosphate Level of the Soil	11
KASK, R. P., Water Erosion of Soils in Estonian SSR	9
KATALYMOV, M. V. and S. I. RYABOVA, Content and Methods of Determination of Soluble Boron in Soils	8
KATS, N. YA., Distribution of Bog Types in Frigid and Temperate Zones of the Northern Hemisphere	6
KAURICHEV, I. S., Formation and Migration of Organic Iron Compounds in Soils	12
KLECHKOVSKIY, V. M. and I. V. GULYAKIN, The Behavior in Soils and Plants of Traces of Strontium, Cesium, Ruthenium and Zirconium	3
KOVDA, V. A., B. A. ZIMOVETS and A. G. AMCHISLAVSKAYA, Hydrogenic Accumulation of Silica Compounds and Sesquioxides in Soils of the Amur Foreland	5
KOVDA, V. A. and V. S. MURATOVA, Professor E. W. Hilgard (1833-1916)	3
KUZNETSOVA, T. V., Some Properties of Takyrs on the Kizyl-Arvat Plain, Southwestern Turkmenistan	5
LAGUNOVA, YE. P., Humus Formation in Irrigated Sierozems of the Samarkand Oasis	8

INDEX

Number

LAKTIONOV, B. I., Use of Gypsum on Solonized Chestnut Soils of the Southern Ukraine to Increase Fertility 2

LEBEDEV, V. I., Basic Factors Determining Adsorption and Exchange of Ions in Soils 6

LEGOSTAYEV, V. M., Soil Reclamation on the Golodnaya Steppe 1

LIN', TSZIN'-LYAN, Soil Conditions and Experience in Tea Culture in the Principal Tea-Producing Regions of the Eastern Part of Futszyan' Province, Chinese Peoples' Republic 1

MAKSIMYUK, G. P., An Experimental Study of the Leaching Process of Solonchak-Like Solonetzes 8

MALANDINA, A. P., Changes in the Salt Regime After Irrigation of Solonetz-Like Dark Chestnut Soils on the Eastern Volga Bank 7

MALYSHKIN, M. N., Experiment in Soil Productivity Ratings of Novosibirsk Region 4

MANSKAYA, S. M., T. V. DROZDOVA and M. P. YEMEL'YANOVA, Copper Fixation by Various Forms of Natural Organic Compounds 6

MILCHEV, M. P., Some Popular Agricultural Measures for Erosion Control in Bulgaria 8

MIRIMANYAN, KH. B., Bog Soils of Armenia and Their Practical Use 7

MOLODTSOV, V. A., Characteristics of Irrigated Alluvial Soils on the Samarkand Oasis 2

MOTSERELIYA, A. V., Warping the Bogs of Colchis 3

MURATOVA, V. S., Salt Accumulation Processes in the Soils and Ground Water of the Mil'sk Plain, Kura-Araks Lowland 6

NADEZHDIN, B. V., Sod-Carbonate Soils of the Southern Central Siberian Plateau 6

ORLOV, A. YA., Oxygen Content in Ground Waters of Some Forest Soil Groups of the Vologda Oblast' 12

PALETSKAYA, L. N., A. P. LAVROV and SH. I. KOGAN, Pore Formation in Takyr Crust 3

PANIN, P. S., Basic Soil Groups of the Dzungaria and the Adjoining Tian Shan and Altai Mountains 3

PARFENOVA, YE. I. and YE. A. YARILOVA, Problems and Methods of Microscopic and Mineralogic Soil Investigations 12

POKHITON, P. P., The Effect of Various Tree Species on Soil 6

PONOMAREVA, V. V., The Nature and Factors of Soil Formation 9

REMEZOV, N. P., Relation Between Biological Accumulation and Eluvial Process Under Forest Cover 6

REYNTAM, L. YU., Delineation of Regional Agricultural Soils as Demonstrated in Southeast Estonia 8

RODE, A. A., Factors in Soil Formation and the Soil-Forming Process 9

INDEX

Number

ROSLIKOVA, V. I., Some Specific Characteristics of the Meadow Soils of the Southern Maritime Region 5

ROZOV, N. N., et al., Second Plenum of the Committee on the Nomenclature, Systematics and Classification of Soils of the Academy of Sciences, USSR 9

SHRAG, V. I., Impervious Linings in Subsurface Soils 7

SKORODUMOV, A. S., Water Relations of Clay Loams on Forest Plantations in the Steppe and Forest-Steppe 3

SKRYNNIKOVA, I. N., Current Soil Processes in the Southern Forest Zone 4

SMIRNOV, V. N., Nutrient Element Dynamics and Biological Activity of Podzols from the Southern Forest Zone 7

SMIRNOVA, K. M. and G. I. GLEBOVA, Content of Mobile Compounds in Podzolic Soils of the Moscow Region 8

SOBOLEV, S. S. and M. N. MALYSHKIN, Problems in the Qualitative Evaluation of Soils of the USSR 9

SOKOLOV, A. V., Supply of Available Soil Phosphates and Their Accumulation When Phosphorus Fertilizers are Applied 2

SOKOLOV, A. V., Soil Conditions Affecting Fertilizer Efficiency 9

SOKOLOV, I. A., The Meadow-Steppe Soils of the Eastern Transbaykal 11

STRANSKI, IVAN, The Contribution of Soviet Soil Science to the Study of Bulgarian Soils 6

TAYCHINOV, S. N. and M. M. FAYZULLIN, Dynamics of Soil Moisture in Relation to Topography 10

TAZABEKOV, T. T., Salt-Water Relations and Hydrophysical Properties of the Caspian Sea, Northern Shore 6

TREPETSOV, YE. V., Development of Gullies in the Ob' Region 5

TURLYUN, I. A., The Nature of Gas and Vapor Transfer in Soil Materials 9

TYSHKEVICH, T. L., Soils Under Spruce Forests of the Carpathians 2

TYURIN, I. V., Immediate and Essential Problems of Soviet Soil Scientists 8

VAYCHIS, M. V., Influence of European Larch on Changes in Sod-Podzolic Soils 5

VERIGINA, K. V., Characteristics of Soil Formation Under Forest and Plowed Land in Kalingrad Region 5

VERSHININ, P. V., Synthetic Soil Conditioners 10

VLADYCHENSKIY, S. A., Effect of Water Reservoirs on Soils 9

VOLOBUYEV, V. R., Some Questions of the Energetics of Soil Formation 7

YEVDOKIMOVA, T. I. and L. A. RUDINA, The Role of Grass Vegetation in Soil Formation on the Moscow River Flood Plain 9

YEGOROV, V. V., A Classification Scheme for Delta Soils of the Arid Regions of the USSR 11

INDEX

Number

ZABOYEVA, I. V., Gley-Podzolic Soils 3

ZAVALISHIN, A. A., Dokuchayev's Doctrine on Factors in Soil Formation as a Basis for the Comparative Geographical Method of Soil Investigation 9

ZAYDEL'MAN, F. R., Distribution of Plant Root Systems in Soils Underlain by Gravel and Some of Their Specific Irrigational Characteristics 6

ZONN, S. V. and LI CHEN-KVEY, Problems in Genesis and Classification of the Tropical Soils of China 9

DISCUSSION

AFANAS'YEVA, YE. A. and P. U. BAKHTIN, Classification of Soils Transitional From Meadow Soils to Chernozems of the Forest-Steppe Belt, West Siberian Lowland 7

DOBROVOL'SKIY, G. V., Classification of Bottom Land Soils in the Forest Zone 8

GAVRILYUK, F. YA., Soil Classification of Rostov Region 5

IVANOVA, YE. N. and N. N. ROZOV, The Status and Development of Classification Problems in Soil Science 10

IVANOVA, YE. N. and N. N. ROZOV, An Attempt at a Systematic Classification of the Soils in the Steppe Zone of the USSR 12

MAKEYEV, O. V. and N. A. NOGINA, Genus of Sod-Forest Soils on Residual-Alluvial Traps 7

MEIYERSON, G. M., Some Questions of the Agronomic Characterization of Land Resources for Land Use Purposes 1

VOLOBUYEV, V. R., A Comparative Geographical Study of Climatic Conditions of Chernozem Formation (Contribution to a Discussion of Chernozem Classification) 8

METHODS

ADERIKHIN, P. G. and YE. P. TIKHOVA, Color Changes of Northern Surface Soils 10

AGAKHANYANTS, O. YE., Soils of the Western Pamir 1

ALEKSIN, A. A., Zonal Distribution of Calcite in Soils and Substrata of the Amu-Dar'ya Delta 2

ALOV, A. S., Plant Nutrients in Structured Soils 3

ANDRONIKOV, V. L., Improving Survey Techniques for Soil Mapping 8

BAZILEVSKAYA, YE. S., Distinctive Features of the Percolation Properties of Soils and Suspended Matter in the Amu-Dar'ya River 4

BERG, L. G. and N. V. SITNIKOV, Rapid Determination of Soil Moisture by the Hydride Method 5

BYKOVA, L. N., A Method for Chemical Analysis of Roots 9

CHERNYSHEVA, A. P., Effect of Forest Plantings on Some Hydrophysical Properties of Chernozems 6

DAVTYAN, G. S., Principles of the Agrochemical Characterization of Soils 5

INDEX

	Number
DIMO, N. A., A Portable Mechanized Auger for Taking Soil Samples	11
DMITRIYEVA, N. V., The Brown Forest Soils of the Kodry	7
DOBRYAKOV, N. F., Field Determination of the Structural Condition of the Soil by the Rate of Change of its Permeability	4
DOLGILEVICH, M. I., A Method for Measuring the Wind Erosion Depth of Soils	8
DUSHCHENKO, V. P., Physical Nature of the Second Critical Point on Curves of the Drying Rate of Soils (Clays)	5
FAT'YANOV, A. S., Some Characteristics of the Reaction Between Soils and Fulvic Acid Solutions	8
FIRSOVA, YE. S., Minimum Moisture Capacity of Soils	2
FIRSOVA, YE. S., Effect of Parent Materials on the Erosive Action on the Right Bank of the Oka River	9
GAVRILOV, K. A. and T. S. PEREL', Earthworms and Other Invertebrates Inhabiting Forest Soils in the Vologda Region	8
GAYEL', A. G. and A. S. PLACHINDA, Surface Runoff on Sands	4
GINZBURG, K. YE., Colorimetric Methods for Determining Phosphorus in Acid Extracts of Soils	2
GRADUSOV, B. P., Effect of Forest Litters on Chemical Properties of Soils in the Southern Taiga Subzone	8
IL'IN, I. R., Methods of Determining Total Soil Water Content With Various Kinds of Tillage	6
KACHINSKIY, A. A., Use of Soil Texture to Evaluate Natural Fertility and Basic Soil Properties for Agronomic Purposes	5
KARLOV, YE. M., Causes of Plant Cover Patchiness in Eastern Kazakhstan	5
KARNAUKHOV, B. G., An Evaluation of Some Methods of Determining the Wilting Moisture	6
KATSAS, M. M. and G. I. ROZOVSKIS, The Use of Some Indices of the Soil's Liming Requirement and the Interrelationship Between Them	11
KONONOVA, M. M., N. P. BEL'CHIKOVA and V. K. NIKIFOROV, Use of the Chromatographic Method in Studying Humic Substances of the Soil	3
KOROLEVA, O. N., Dynamics of Nitrates and Moisture in Ordinary Chernozems of Different Land Uses in the Kuybyshev Oblast'	10
KOROVKINA, A. V., The Quality of Water-Stable Aggregates and Their Composition by Groups as Determined by A. F. Tyulin's Method	4
KOSHEL'KOV, P. N., U. G. OKSENT'YAN, Z. M. OSIPOVA and D. V. KHAR'KOV, Importance of Manure and Mineral Fertilizers in Raising Fertility of Sod-Podzolic Soils	6
KOVDA, V. A. and V. D. VASIL'YEVSKAYA, A Study of the Minor Element Contents in Soils of the Amur River Area	12
KRAVITSOVA, V. I., Experience in Using 1:100, 000 Topographic Maps for Compiling 1:1, 000, 000 Soil Maps	1

INDEX

	Number
KREYDA, N. A., Soils of the Eastern European Tundras	1
KULIK, N. F., Water Regime of Virgin Steppe Areas in the Sands of Terek and Kuma Rivers	9
MAKAROV, B. N. and V. B. MATSKEVICH, Terminology of "Soil Respiration" and "Biological Activity of the Soil"	6
MALEINA, A. A., A Method of Determining the Reserve of Available Soil Phosphates	4
MALINKIN, N. P., Organic Matter Content of Irrigated Sierozems in Central Asia	6
MARTYNOV, V. P., Refinement of the Geysler-Maksimyuk Calcimeter	5
MATYUK, I. S., Some Types of Sandhills on the Don River	8
MIKHEL'SON, KH. K., Determination of Available Potassium Content of Soils by Means of an Illuminating-Gas Flame Photometer	11
MINASHINA, N. G., Optically Oriented Clays in Soils	4
MOSHEV, A. I., Determination of Soil Colloid Adsorption Capacity	6
MOSIYENKO, N. A., Water Permeability of Frozen Soil at Kulunda Steppe	9
MYAKINA, N. B., A Modified Kjeldahl Method for the Determination of Total Nitrogen	1
NIKOLAYEVA, T. A., Seasonal Changes in Composition of Organic Matter in Drained, Cultivated Bog Soils	12
OGANESYAN, A. P., A Simplified Method for Determining Soil Moisture	4
PALAVEYEV, T., Boron in Chernozems and Gray Forest Soils of Northern Bulgaria	9
POL'SKIY, B. N., Texture of Alluvial Soils as Related to the Development of a Flood Plain	7
POL'SKIY, M. N., Modification of the BP-44 Auger for Use on Compacted Soils.	9
POL'SKIY, M. N., Methods Used in the Treatment, Graphic Representation and Analysis of Data on the Soil Moisture Dynamics	11
POPOV, A. A., Some Questions on Genesis of Chestnut Soils in the Semihumid Subtropics of the Eastern Transcaucasus	3
PUGACH, F. I., Shortcomings in the Elucidation of Soils in the Secondary School Course in Geography	8
SAZANOV, V. I., and A. G. SERGEYEVA, The Effect of Alfalfa and Sainfoin on the Availability of Phosphorus in Irrigated Chernozem Soils	5
SEYFERT, YAROMIR, Use of Fluorescence Microscopy in Soil Microbiology	2
SEMENOVA, N. N., Separation of Certain North Kazakhstan Soil Complexes on Aerial Photographs	8
SHOPKHOYEV, S. P., Vertical Migration of Nitrates in Chernozem Stavropol Plateau	6

INDEX

Number

SKOBETS, YE. M., I. L. ABARBARCHUK, K. P. KOSTITSINA, and N. I. BEL'SKAYA, Polarographic Analysis of Soils Determination of Adsorptive Capacity 1

SUDNITSYN, I. I., Effect of Functional Soil Moisture Properties on the Rate of Moisture Uptake by Woody Plants 11

SUKHACHEV, S. I., Salinization of Soils at the Periphery of the Sokh Alluvial Fan 1

SUKHAREV, I. P. and YE. M. SUKHAREVA, Effect of Agricultural Practices on Water Intake of Soil 3

SVATKOV, N. M., Soils of Wrangel Island 1

TALPSEPP, E. YA., Effect of Liming on Physicochemical and Physical Soil Properties in the Southern Estonian SSR 3

TIKHOVA, YE. P., The Importance of Exchangeable Cations in the Adsorption of $SO_4^{=}$ by Soils 2

TSERLING, V. V., Methods of Diagnosing the Nitrogen Requirement of Plants 1

TYAGNY-RYADNO, M. G., Biophysical and Chemical Analysis of Soil Aggregates 12

VINOKUROV, M. A. and A. N. TYURMENKO, Materials in the Forest's Biological Cycle of Nitrogen and Phosphorus 7

VLADYCHENSKIY, S. A., Some Notes on Types of Water Relations 6

YAROVENKO, V. V., The Agronomic Importance of Soil Density 5

YASTREBOV, M. YA., Effect of the Major Biological Factors on Air Composition of Alluvial Soils in the Klyaz'ma River Flood Plain 10

YEGOROV, V. P., Soil Complexes of the West Bank of the Irtysh in the Subzone of Dark Chestnut Soils 3

ZAKHARCHENKO, A. F., Variance Analysis in Microbiological Research 3

ZHUKOV, M. S., Acidity Changes in Sandy Soils as Affected by the Hill Method of Applying Fertilizers 10

BOOK REVIEWS

BEAR, FIRMAN E. (Editor), Chemistry of the Soil (Reviewed by I. Renezov) 10

CHEREMESINOV, G. A., Control of Drought and Soil Erosion (Reviewed by Surmach, G. P.) 5

DAMES, T. V. J., Valuable Research on Tropical Soils — The Soils of East Central Java (Reviewed by V. M. Fridland) 10

GERASIMOV, I. P., A New Scientific Work on the Mountain-Forest Soils of Bulgaria (Reviewed by S. W. Zonn) 5

GORBUNOV, N. I., Soil Colloids, Popular Scientific Series of the Press of the Academy of Sciences, USSR. 1957 (Reviewed by Ye. P. Troitskiy) 12

KELLEY, W. P., Alkali Soils (Reviewed by V. S. Muratova) 2

Manual of Laboratory and Field Methods (Reviewed by Gorbunov, N. I. and N. Ye. Bekarevich) 7

INDEX

	Number
MONIN, S. A., Soil Geography and Fundamentals of Soil Science (Reviewed by S. I. Sokolov)	7
MÜCKENHAUSEN, PROFESSOR DR. E., Die Wichtigsten Böden der Bundesrepublick Deutschland (Reviewed by S. W. Zonn)	2
Scientific Publications of the N. Pushkarov Institute of Soil Research. Book I, 1956, Sofiya. (Reviewed by Antipov-Karatayev, I. N.)	1

CHRONICLE

ADERIKHIN, P., Activities of the Voronezh Division of the All-Union Society of Soil Scientists	2
ADERIKHIN, P. G., The Results of the First Inter-Oblast' Conference of Soil Scientists of the Central Chernozem Zone	12
ALEKPEROV, K. A., The Baku Conference on Soil Erosion and its Control	5
ALEKSEY GRIGOR'YEVICH DOYARENKO	10
ALEKSEY NIKOLAYEVICH KOSTYAKOV	2
ALEYEV, G. A., The Activities of the Azerbaydzhan Branch of the All-Union Society of Soil Scientists	11
ANTIPOV-KARATAYEV, I. N., The 70th Birthday of	12
Award of the V. V. Dokuchayev Gold Medal and the V. R. Vil'Yams Prizes	2
BAZHENOV, N. K., The Work of the Kirghiz Branch of the All-Union Society of Soil Scientists	11
BLAZHNIY, YE. S., Work of the Krasnodar Division of the All-Union Society of Soil Scientists	7
BUROV, D. I., Basic Results of the Work and Future Tasks of the Kuybyshev Division of the All-Union Society of Soil Scientists	10
CHULAKOV, SH. A., Second Republic Conference of Kazakhstan Soil Scientists	10
DZHUMAYEV, O. M., The Activities of the Turkmenian Branch of the All-Union Society of Soil Scientists	12
GEDEVANISHVILI, D. P., The Activities of the Georgian Branch of the All-Union Society of Soil Scientists	12
GORSHENIN, K. P., The 70th Birthday of, and the Forty-Fifth Anniversary of His Scientific and Teaching Activities	6
GRINCHENKO, A. M., Work of the Session on Problems of Soil Science of the Section on Agriculture, Ukrainian Academy of Agricultural Sciences	10
IVANOV, G. I., Vladivostok Section, All-Union Society of Soil Scientists	4
IVLEV, A. M., A Study of Sakhalin Island Soils	2
KOLOSKOVA, A. V., The Work of the Kazan Branch of the All-Union Society of Soil Scientists for 1957	11
KOLYAGO, S. A., The Work of the Tomsk Section of the All-Union Society of Soil Scientists	11

INDEX

	Number
KONONOVA, MARIYA MIKHAYLOVNA, In Honor of the Sixtieth Anniversary of Her Birth	11
KONONOVA, M. M. and I. N. ANTIPOV-KARATAYEV, Institutions for Scientific Soil Research, Federal Republic of Germany (Jan. 23-Feb. 10)	5
KRUMIN'SH, K., Report of the Latvian Branch All-Union Society of Soil Scientists for 1957	8
KUZNETSOV, K. A., The Work of the Penza Section of the All-Union Association of Soil Scientists	12
MAYBORODA, N. M., The Krasnoyarsk Section of the All-Union Society of Soil Scientists	5
ORLOVSKIY, N. V., The Work Conducted by the Members of the Altay Branch of the All-Union Society of Soil Scientists in 1957	11
PRUDNIKOVA, V. M., The Work of the Omsk Branch of the All-Union Society of Soil Scientists for 1957	11
RADOV, A. S., Status and Development of Agricultural Chemistry in the Bulgarian People's Republic	1
RAZORENOVA, N. A., Activities of the All-Union Society of Soil Scientists of the USSR During 1957	4
REVUT, I. B., Soil Physics in the Scientific Research Institute of Agricultural Physics	11
RUBINSHTEYN, M. I., Kazakhstan Section, All-Union Society of Soil Scientists	4
SADIMENKO, P. A., The Work of the Rostov Section of the All-Union Society of Soil Scientists	12
SAMBUR, G. N., The Work of the Kiev Section of the All-Union Society of Soil Scientists	12
SHKONDE, E. I., All-Union Conference on Agricultural Chemical Methods of Soil Investigation	2
SHUVALOV, S. A., First Delegates' Convention of Soil Scientists of the USSR	9
SOKOLOV, ANDREY VASIL'YEVICH, In Honor of the Sixtieth Anniversary of His Birth	11
SOLDATOV, A. S., The Work of the Dagestan Division of the All-Union Society of Soil Scientists	10
TAYCHINOV, S. N. and M. S. SHIGAYEV, The Work of the Bashkir Division of the All-Union Society of Soil Scientists	2
TUMIN, GRIGORIY MIKHAYLOVICH (1876-1957)	11
YELOVSKAYA, L. G., Work Accomplished in 1957 by the Yakutsk Section of the All-Union Society of Soil Scientists	11
YEROKHINA, A. A., Activities of Commissions of the International Society of Soil Scientists and of Societies of Soil Scientists of Various Countries	4
ZABOYEVA, I. V., The Work of the Komi Section of the All-Union Society of Soil Scientists in 1957	12

AIBS Russian Monograph Translations

The AIBS is in the process of expanding its Russian Translations Program extensively. Funds to subsidize translation and publication of important Russian literature in biology have been obtained from the National Science Foundation, as part of a larger program to encourage the exchange of scientific information between the two countries. The following monographs have been scheduled for publication:

Origins of Angiospermous Plants. *By A. L. Takhtajan*
Edited by G. Ledyard Stebbins. Translated by Olga H. Gankin
68 pp. [13 illustrations] 8½ x 10¾. $3.00, individuals and industrial libraries (U.S. & Canada); $2.00, AIBS members and all other libraries; $.50, additional, foreign.

Essays on the Evolutionary Morphology of Plants. *By A. L. Takhtajan*
Edited by G. Ledyard Stebbins. Translated by Olga H. Gankin
144 pp. [32 illustrations] 8½ x 10¾. $5.00, individuals and industrial libraries (U.S. & Canada); $4.00, AIBS members and all other libraries; $.50, additional, foreign.

Problems in the Classification of Antagonists of Actinomycetes. *By G. F. Gause*
Edited by David Gottlieb. Translated by Fritz Danga
165 pp. [18 illustrations] 7 x 10. $5.00, individuals and industrial libraries (U.S. & Canada); $4.00, AIBS members and all other libraries; $.50, additional, foreign.

Arachnida. Vol. IV, No. 2. Fauna of the U.S.S.R. *By B. I. Pomerantzev.*
Edited by George Anastos. Translated by Alena Elbl.
199 pp. [638 illustrations] 7 x 10. $10.00, individuals and industrial libraries (U.S. & Canada); $9.00, AIBS members and all other libraries; $1.00, additional, foreign.

Arachnoidea. Vol. VI, No. 1. Fauna of the U.S.S.R. *By A. A. Zachvatkin*
Translated and edited by A. Ratcliffe and A. M. Hughes
567 pp. [705 illustrations] 7 x 10. $10.00, individuals and industrial libraries (U.S. & Canada); $9.00, AIBS members and all other libraries; $1.00, additional, foreign.

Marine Biology. Trudy Institute of Oceanology. Vol. XX. *Edited by B. N. Nikitin*
302 pp. [66 illustrations] 8½ x 10¾. $10.00, individuals and industrial libraries; (U.S. & Canada); $7.50, AIBS members and all other libraries; $1.00, additional, foreign.

Plants and Xrays. *By L. P. Breslavets*
Editor of English Edition: Arnold H. Sparrow
115 pp. [26 illustrations] 7 x 10. $5.00, individuals and industrial libraries (U.S. & Canada); $4.00, AIBS members and all other libraries; $.50, additional, foreign.

For orders and a FREE copy of our Publications Catalog listing all AIBS Publications, write to:

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES
2000 P Street, N.W. Washington 6, D.C.

RONOMY SEMINAR
5 DAVENPORT HALL

TRANSLATIONS OF RUSSIAN BIOLOGICAL JOURNALS

The American Institute of Biological Sciences, under a grant from the National Science Foundation, is currently translating and publishing seven Russian research journals in biology.

DOKLADY: BIOLOGICAL SCIENCES SECTION

6 issues per year. First issues published: 1957, Vols. 112-117. Current issues published: 1960, Vols. 130-135.

Subscriptions:

$20.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$15.00 per year, AIBS members and all other libraries
$2.50 additional to each price, foreign
$4.00 each, single copies

DOKLADY: BOTANICAL SCIENCES SECTION

6 issues per year. First issues published: 1957, Vols. 112-117. Current issues published: 1960, Vols. 130-135.

Subscriptions:

$7.50 per year, individuals and industrial libraries (U.S.A. & Canada)
$5.75 per year, AIBS members and all other libraries
$1.50 additional to each price, foreign
$1.50 each, single copies

DOKLADY: BIOCHEMISTRY SECTION

6 issues per year. First issues published: 1957, Vols. 112-117. Current issues published: 1960, Vols. 130-135.

Subscriptions:

$15.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$10.00 per year, AIBS members and all other libraries
$3.00 additional to each price, foreign
$4.50 each, single copies

PLANT PHYSIOLOGY • FIZIOLOGIYA RASTENIY

6 issues per year. First issues published: 1957. Vol. 4, Nos. 1-6. Current issues published: 1960, Vol. 7, Nos. 1-6.

Subscriptions:

$15.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$11.00 per year, AIBS members and all other libraries
$2.00 additional to each price, foreign
$3.00 each, single copies

MICROBIOLOGY • MIKROBIOLOGIYA

6 issues per year. First issues published: 1957, Vol. 26, Nos. 1-6. Current issues published: 1960, Vol. 29, Nos. 1-6.

Subscriptions:

$20.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$15.00 per year, AIBS members and all other libraries
$2.50 additional to each price, foreign
$4.00 each, single copies

SOVIET SOIL SCIENCE • POCHVOVEDENIYE

12 issues per year. First issues published: 1958. Current issues published: Jan.-Dec., 1959.

Subscriptions:

$40.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$20.00 per year, AIBS members and all other libraries
$3.00 additional to each price, foreign
$4.50 each, single copies

ENTOMOLOGICAL REVIEW
ENTOMOLOGICHESKOYE OBOZRENIYE

4 issues per year. First issues published: 1958. Current issues published: 1960, Vol. 39, Nos. 1-4.

Subscriptions:

$25.00 per year, individuals and industrial libraries (U.S.A. & Canada)
$12.00 per year, AIBS members and all other libraries
$3.00 additional to each price, foreign
$7.50 each, single copies

Order from:

AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES
2000 P Street, N.W. Washington 6, D.C.